Linux CLI Beginner Course

Linux Starterscourse

Publication Date
10.01.2020

Author
Gert Van Waeyenberg

History
Previous versions of this document
Linux Fundamentals - 09.27.2014 - Paul Cobbaut

Previous Authors
Paul Cobbaut: paul.cobbaut@gmail.com, http://www.linkedin.com/in/cobbaut

Credits
All credits goes to Paul Cobbaut for making this great documentation.

Modifications
I merely did some changes/updates and some minor additions in my attempt to make the course more up to date and to cover a little more commands/options.
I removed the first four chapters that didn't discuss the CLI and the last two chapters that in my opinion are more advanced topics

Free Documentation

GNU Free Documentation License

GNU Free Documentation License Version 1.3, 3 November 2008 Copyright © 2000, 2001, 2002, 2007, 2008 Free Software Foundation, Inc. Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed. 0. PREAMBLE The purpose of this License is to make a manual, textbook, or other functional and useful document "free" in the sense of freedom: to assure everyone the effective freedom to copy and redistribute it, with or without modifying it, either commercially or noncommercially. Secondarily, this License preserves for the author and publisher a way to get credit for their work, while not being considered responsible for modifications made by others. This License is a kind of "copyleft", which means that derivative works of the document must themselves be free in the same sense. It complements the GNU General Public License, which is a copyleft license designed for free software. We have designed this License in order to use it for manuals for free software, because free software needs free documentation: a free program should come with manuals providing the same freedoms that the software does. But this License is not limited to software manuals; it can be used for any textual work, regardless of subject matter or whether it is published as a printed book. We recommend this License principally for works whose purpose is instruction or reference. 1. APPLICABILITY AND DEFINITIONS This License applies to any manual or other work, in any medium, that contains a notice placed by the copyright holder saying it can be distributed under the terms of this License. Such a notice grants a world-wide, royalty-free license, unlimited in duration, to use that work under the conditions stated herein. The "Document", below, refers to any such manual or work. Any member of the public is a licensee, and is addressed as "you". You accept the license if you copy, modify or distribute the work in a way requiring permission under copyright law. A "Modified Version" of the Document means any work containing the Document or a portion of it, either copied verbatim, or with modifications and/or translated into another language. A "Secondary Section" is a named appendix or a front-matter section of the Document that deals exclusively with the relationship of the publishers or authors of the Document to the Document's overall subject (or to related matters) and contains nothing that could fall directly within that overall subject. (Thus, if the Document is in part a textbook of mathematics, a Secondary Section may not explain any mathematics.) The relationship could be a matter of historical connection with the subject or with related matters, or of legal, commercial, philosophical, ethical or political position regarding them. The "Invariant Sections" are certain Secondary Sections whose titles License 283 are designated, as being those of Invariant Sections, in the notice that says that the Document is released under this License. If a section does not fit the above definition of Secondary then it is not allowed to be designated as Invariant. The Document may contain zero Invariant Sections. If the Document does not identify any Invariant Sections then there are none. The "Cover Texts" are certain short passages of text that are listed, as Front-Cover Texts or Back-Cover Texts, in the notice that says that the Document is released under this License. A Front-Cover Text may be at most 5 words, and a Back-Cover Text may be at most 25 words. A "Transparent" copy of the Document means a machine-readable copy, represented in a format whose specification is available to the general public, that is suitable for revising the document straightforwardly with generic text editors or (for images composed of pixels) generic paint programs or (for drawings) some widely available drawing editor, and that is suitable for input to text formatters or for automatic translation to a variety of formats suitable for input to text formatters. A copy made in an otherwise Transparent file format whose markup, or absence of markup, has been arranged to thwart or discourage subsequent modification by readers is not Transparent. An image format is not Transparent if used for any substantial amount of text. A copy that is not "Transparent" is

called "Opaque". Examples of suitable formats for Transparent copies include plain ASCII without markup, Texinfo input format, LaTeX input format, SGML or XML using a publicly available DTD, and standard-conforming simple HTML, PostScript or PDF designed for human modification. Examples of transparent image formats include PNG, XCF and JPG. Opaque formats include proprietary formats that can be read and edited only by proprietary word processors, SGML or XML for which the DTD and/or processing tools are not generally available, and the machine-generated HTML, PostScript or PDF produced by some word processors for output purposes only. The "Title Page" means, for a printed book, the title page itself, plus such following pages as are needed to hold, legibly, the material this License requires to appear in the title page. For works in formats which do not have any title page as such, "Title Page" means the text near the most prominent appearance of the work's title, preceding the beginning of the body of the text. The "publisher" means any person or entity that distributes copies of the Document to the public. A section "Entitled XYZ" means a named subunit of the Document whose title either is precisely XYZ or contains XYZ in parentheses following text that translates XYZ in another language. (Here XYZ stands for a specific section name mentioned below, such as "Acknowledgements", "Dedications", "Endorsements", or "History".) To "Preserve the Title" of such a section when you modify the Document means that it remains a section "Entitled XYZ" according to this definition. The Document may include Warranty Disclaimers next to the notice which states that this License applies to the Document. These Warranty Disclaimers are considered to be included by reference in this License, but only as regards disclaiming warranties: any other implication that these Warranty Disclaimers may have is void and has no effect on the meaning of this License. 2. VERBATIM COPYING You may copy and distribute the Document in any medium, either License 284 commercially or noncommercially, provided that this License, the copyright notices, and the license notice saying this License applies to the Document are reproduced in all copies, and that you add no other conditions whatsoever to those of this License. You may not use technical measures to obstruct or control the reading or further copying of the copies you make or distribute. However, you may accept compensation in exchange for copies. If you distribute a large enough number of copies you must also follow the conditions in section 3. You may also lend copies, under the same conditions stated above, and you may publicly display copies. 3. COPYING IN QUANTITY If you publish printed copies (or copies in media that commonly have printed covers) of the Document, numbering more than 100, and the Document's license notice requires Cover Texts, you must enclose the copies in covers that carry, clearly and legibly, all these Cover Texts: Front-Cover Texts on the front cover, and Back-Cover Texts on the back cover. Both covers must also clearly and legibly identify you as the publisher of these copies. The front cover must present the full title with all words of the title equally prominent and visible. You may add other material on the covers in addition. Copying with changes limited to the covers, as long as they preserve the title of the Document and satisfy these conditions, can be treated as verbatim copying in other respects. If the required texts for either cover are too voluminous to fit legibly, you should put the first ones listed (as many as fit reasonably) on the actual cover, and continue the rest onto adjacent pages. If you publish or distribute Opaque copies of the Document numbering more than 100, you must either include a machine-readable Transparent copy along with each Opaque copy, or state in or with each Opaque copy a computer-network location from which the general network-using public has access to download using public-standard network protocols a complete Transparent copy of the Document, free of added material. If you use the latter option, you must take reasonably prudent steps, when you begin distribution of Opaque copies in quantity, to ensure that this Transparent copy will remain thus accessible at the stated location until at least one year after the last time you distribute an Opaque copy (directly or through your agents or retailers) of that edition to the public. It is requested, but not required, that you contact the authors of the Document well before

redistributing any large number of copies, to give them a chance to provide you with an updated version of the Document. 4. MODIFICATIONS You may copy and distribute a Modified Version of the Document under the conditions of sections 2 and 3 above, provided that you release the Modified Version under precisely this License, with the Modified Version filling the role of the Document, thus licensing distribution and modification of the Modified Version to whoever possesses a copy of it. In addition, you must do these things in the Modified Version: * A. Use in the Title Page (and on the covers, if any) a title distinct from that of the Document, and from those of previous versions (which should, if there were any, be listed in the History section of the Document). You may use the same title as a previous version if the original publisher of that version gives permission. License 285 * B. List on the Title Page, as authors, one or more persons or entities responsible for authorship of the modifications in the Modified Version, together with at least five of the principal authors of the Document (all of its principal authors, if it has fewer than five), unless they release you from this requirement. * C. State on the Title page the name of the publisher of the Modified Version, as the publisher. * D. Preserve all the copyright notices of the Document. * E. Add an appropriate copyright notice for your modifications adjacent to the other copyright notices. * F. Include, immediately after the copyright notices, a license notice giving the public permission to use the Modified Version under the terms of this License, in the form shown in the Addendum below. * G. Preserve in that license notice the full lists of Invariant Sections and required Cover Texts given in the Document's license notice. * H. Include an unaltered copy of this License. * I. Preserve the section Entitled "History", Preserve its Title, and add to it an item stating at least the title, year, new authors, and publisher of the Modified Version as given on the Title Page. If there is no section Entitled "History" in the Document, create one stating the title, year, authors, and publisher of the Document as given on its Title Page, then add an item describing the Modified Version as stated in the previous sentence. * J. Preserve the network location, if any, given in the Document for public access to a Transparent copy of the Document, and likewise the network locations given in the Document for previous versions it was based on. These may be placed in the "History" section. You may omit a network location for a work that was published at least four years before the Document itself, or if the original publisher of the version it refers to gives permission. * K. For any section Entitled "Acknowledgements" or "Dedications", Preserve the Title of the section, and preserve in the section all the substance and tone of each of the contributor acknowledgements and/or dedications given therein. * L. Preserve all the Invariant Sections of the Document, unaltered in their text and in their titles. Section numbers or the equivalent are not considered part of the section titles. * M. Delete any section Entitled "Endorsements". Such a section may not be included in the Modified Version. * N. Do not retitle any existing section to be Entitled "Endorsements" or to conflict in title with any Invariant Section. * O. Preserve any Warranty Disclaimers. If the Modified Version includes new front-matter sections or appendices that qualify as Secondary Sections and contain no material copied from the Document, you may at your option designate some or all of these sections as invariant. To do this, add their titles to the list of Invariant Sections in the Modified Version's license notice. These titles must be distinct from any other section titles. You may add a section Entitled "Endorsements", provided it contains nothing but endorsements of your Modified Version by various parties—for example, statements of peer review or that the text has been approved by an organization as the authoritative definition of a standard. You may add a passage of up to five words as a Front-Cover Text, and a passage of up to 25 words as a Back-Cover Text, to the end of the list of Cover Texts in the Modified Version. Only one passage of Front-Cover Text and one of Back-Cover Text may be added by (or through arrangements made by) any one entity. If the Document already includes a cover text for the same cover, previously added by you or by arrangement made by the same entity you are acting on behalf of, License 286 you may not add another; but you may replace the old one, on explicit permission from

the previous publisher that added the old one. The author(s) and publisher(s) of the Document do not by this License give permission to use their names for publicity for or to assert or imply endorsement of any Modified Version. 5. COMBINING DOCUMENTS You may combine the Document with other documents released under this License, under the terms defined in section 4 above for modified versions, provided that you include in the combination all of the Invariant Sections of all of the original documents, unmodified, and list them all as Invariant Sections of your combined work in its license notice, and that you preserve all their Warranty Disclaimers. The combined work need only contain one copy of this License, and multiple identical Invariant Sections may be replaced with a single copy. If there are multiple Invariant Sections with the same name but different contents, make the title of each such section unique by adding at the end of it, in parentheses, the name of the original author or publisher of that section if known, or else a unique number. Make the same adjustment to the section titles in the list of Invariant Sections in the license notice of the combined work. In the combination, you must combine any sections Entitled "History" in the various original documents, forming one section Entitled "History"; likewise combine any sections Entitled "Acknowledgements", and any sections Entitled "Dedications". You must delete all sections Entitled "Endorsements". 6. COLLECTIONS OF DOCUMENTS You may make a collection consisting of the Document and other documents released under this License, and replace the individual copies of this License in the various documents with a single copy that is included in the collection, provided that you follow the rules of this License for verbatim copying of each of the documents in all other respects. You may extract a single document from such a collection, and distribute it individually under this License, provided you insert a copy of this License into the extracted document, and follow this License in all other respects regarding verbatim copying of that document. 7. AGGREGATION WITH INDEPENDENT WORKS A compilation of the Document or its derivatives with other separate and independent documents or works, in or on a volume of a storage or distribution medium, is called an "aggregate" if the copyright resulting from the compilation is not used to limit the legal rights of the compilation's users beyond what the individual works permit. When the Document is included in an aggregate, this License does not apply to the other works in the aggregate which are not themselves derivative works of the Document. If the Cover Text requirement of section 3 is applicable to these copies of the Document, then if the Document is less than one half of the entire aggregate, the Document's Cover Texts may be placed on covers that bracket the Document within the aggregate, or the electronic equivalent of covers if the Document is in electronic form. Otherwise they must appear on printed covers that bracket the whole aggregate. License 287 8. TRANSLATION Translation is considered a kind of modification, so you may distribute translations of the Document under the terms of section 4. Replacing Invariant Sections with translations requires special permission from their copyright holders, but you may include translations of some or all Invariant Sections in addition to the original versions of these Invariant Sections. You may include a translation of this License, and all the license notices in the Document, and any Warranty Disclaimers, provided that you also include the original English version of this License and the original versions of those notices and disclaimers. In case of a disagreement between the translation and the original version of this License or a notice or disclaimer, the original version will prevail. If a section in the Document is Entitled "Acknowledgements", "Dedications", or "History", the requirement (section 4) to Preserve its Title (section 1) will typically require changing the actual title. 9. TERMINATION You may not copy, modify, sublicense, or distribute the Document except as expressly provided under this License. Any attempt otherwise to copy, modify, sublicense, or distribute it is void, and will automatically terminate your rights under this License. However, if you cease all violation of this License, then your license from a particular copyright holder is reinstated (a) provisionally, unless and until the copyright holder explicitly and finally terminates your license, and (b) permanently, if the copyright holder fails to notify

you of the violation by some reasonable means prior to 60 days after the cessation. Moreover, your license from a particular copyright holder is reinstated permanently if the copyright holder notifies you of the violation by some reasonable means, this is the first time you have received notice of violation of this License (for any work) from that copyright holder, and you cure the violation prior to 30 days after your receipt of the notice. Termination of your rights under this section does not terminate the licenses of parties who have received copies or rights from you under this License. If your rights have been terminated and not permanently reinstated, receipt of a copy of some or all of the same material does not give you any rights to use it. 10. FUTURE REVISIONS OF THIS LICENSE The Free Software Foundation may publish new, revised versions of the GNU Free Documentation License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns. See http://www.gnu.org/copyleft/. Each version of the License is given a distinguishing version number. If the Document specifies that a particular numbered version of this License "or any later version" applies to it, you have the option of following the terms and conditions either of that specified version or of any later version that has been published (not as a draft) by the Free Software Foundation. If the Document does not specify a version number of this License, you may choose any version ever published (not as a draft) by the Free Software Foundation. If the Document specifies License 288 that a proxy can decide which future versions of this License can be used, that proxy's public statement of acceptance of a version permanently authorizes you to choose that version for the Document. 11. RELICENSING "Massive Multiauthor Collaboration Site" (or "MMC Site") means any World Wide Web server that publishes copyrightable works and also provides prominent facilities for anybody to edit those works. A public wiki that anybody can edit is an example of such a server. A "Massive Multiauthor Collaboration" (or "MMC") contained in the site means any set of copyrightable works thus published on the MMC site. "CC-BY-SA" means the Creative Commons Attribution-Share Alike 3.0 license published by Creative Commons Corporation, a not-for-profit corporation with a principal place of business in San Francisco, California, as well as future copyleft versions of that license published by that same organization. "Incorporate" means to publish or republish a Document, in whole or in part, as part of another Document. An MMC is "eligible for relicensing" if it is licensed under this License, and if all works that were first published under this License somewhere other than this MMC, and subsequently incorporated in whole or in part into the MMC, (1) had no cover texts or invariant sections, and (2) were thus incorporated prior to November 1, 2008. The operator of an MMC Site may republish an MMC contained in the site under CC-BY-SA on the same site at any time before August 1, 2009, provided the MMC is eligible for relicensing.

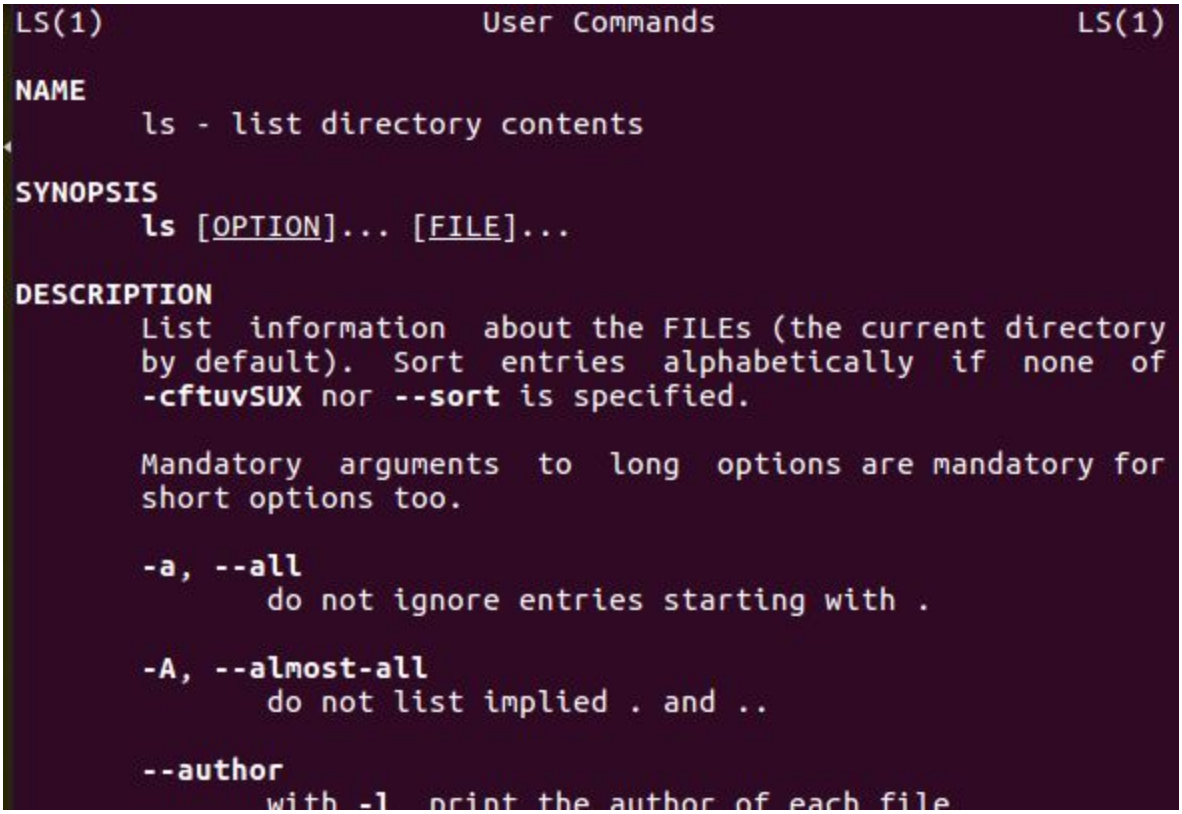
Chapter 5 Man pages

This chapter will explain the use of **man** pages (also called **manual pages**) on your Unix or Linux computer. You will learn the **man** command together with related commands like **whereis**, **whatis** and **mandb**.
Most Unix files and commands have pretty good man pages to explain their use. Man pages also come in handy when you are using multiple flavours of Unix or several Linux distributions since options and parameters sometimes vary.

man $command section 1

Type **man** followed by a command (for which you want help) and start reading. Press **q** to quit the manpage. Some man pages contain examples (near the end).

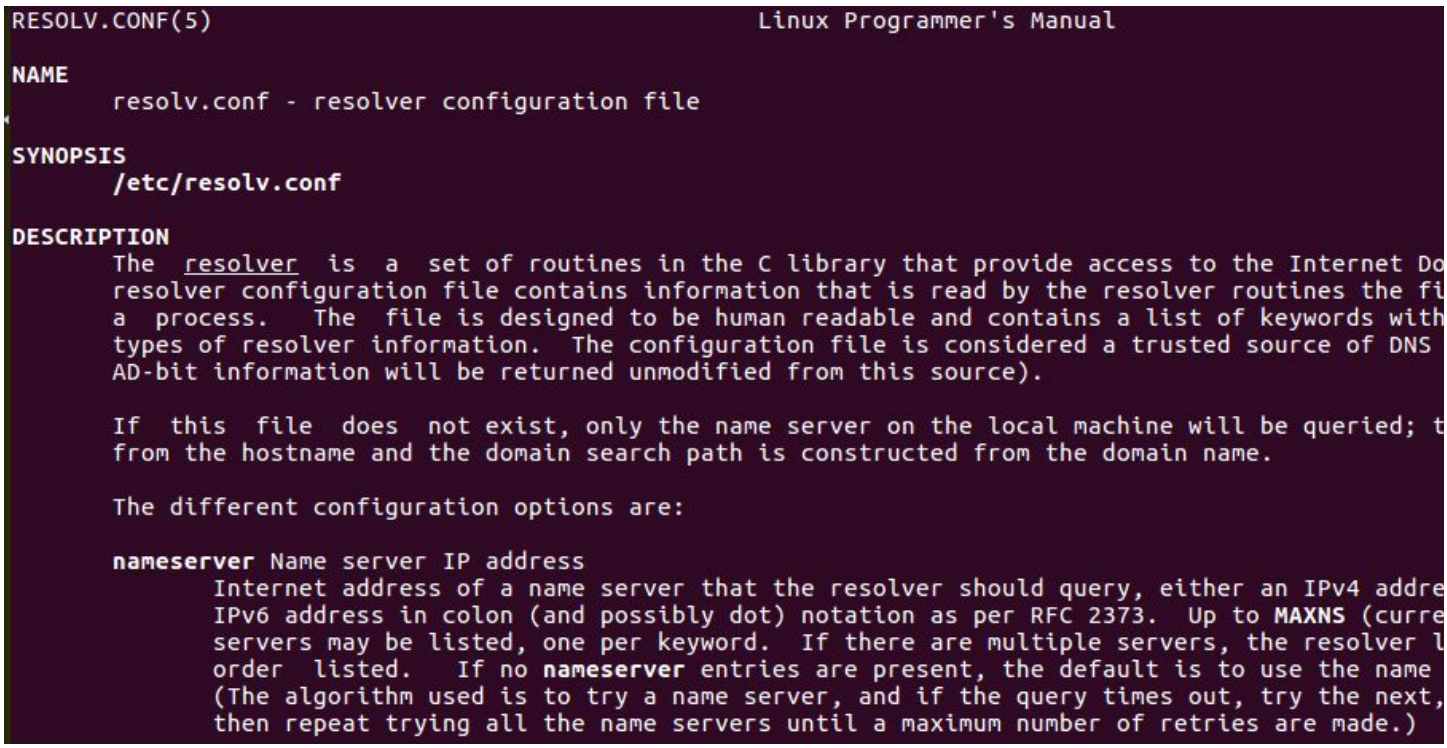
```
gert@ubuntu:~$ man ls
Reformatting ls(1), please wait…
```



man $configfile section 5

Most **configuration files** have their own manual.

```
gert@ubuntu:~$ man resolv.conf
Reformatting resolv.conf(5), please wait...
```



```
RESOLV.CONF(5)                                    Linux Programmer's Manual

NAME
       resolv.conf - resolver configuration file

SYNOPSIS
       /etc/resolv.conf

DESCRIPTION
       The  resolver  is  a  set of routines in the C library that provide access to the Internet Do
       resolver configuration file contains information that is read by the resolver routines the fi
       a  process.   The  file is designed to be human readable and contains a list of keywords with
       types of resolver information.  The configuration file is considered a trusted source of DNS
       AD-bit information will be returned unmodified from this source).

       If  this  file  does  not exist, only the name server on the local machine will be queried; t
       from the hostname and the domain search path is constructed from the domain name.

       The different configuration options are:

       nameserver Name server IP address
              Internet address of a name server that the resolver should query, either an IPv4 addre
              IPv6 address in colon (and possibly dot) notation as per RFC 2373.  Up to MAXNS (curre
              servers may be listed, one per keyword.  If there are multiple servers, the resolver l
              order  listed.   If no nameserver entries are present, the default is to use the name
              (The algorithm used is to try a name server, and if the query times out, try the next,
              then repeat trying all the name servers until a maximum number of retries are made.)
```

man $daemon of man <root-binaries> section 8

This is also true for most **daemons** (background programs) on your system.

```
gert@ubuntu:~$ man systemd-networkd
Reformatting systemd-networkd(8), please wait...
```

```
SYSTEMD-NETWORKD.SERVICE(8)                          systemd-networkd.service

NAME
       systemd-networkd.service, systemd-networkd - Network manager

SYNOPSIS
       systemd-networkd.service

       /lib/systemd/systemd-networkd

DESCRIPTION
       systemd-networkd is a system service that manages networks. It detects and configures
       well as creating virtual network devices.

       To configure low-level link settings independently of networks, see systemd.link(5).

       Network configurations applied before networkd is started are not removed, and static
       is not removed when networkd exits. Dynamic configuration applied by networkd may also
       shutdown. This ensures restarting networkd does not cut the network connection, and, i
       transition between the initrd and the real root, and back.

CONFIGURATION FILES
       The configuration files are read from the files located in the system network director
```

man -k (apropos)

man -k (or **apropos**) shows a list of man pages containing a string.

```
gert@ubuntu:~$ man -k syslog
lm-syslog-setup (8)  - configure laptop mode to switch syslog.conf ...
logger (1)           - a shell command interface to the syslog(3) ...
syslog-facility (8)  - Setup and remove LOCALx facility for sysklogd
syslog.conf (5)      - syslogd(8) configuration file
syslogd (8)          - Linux system logging utilities.
syslogd-listfiles (8) - list system logfiles
```

whatis

To see just the description of a manual page, use **whatis** followed by a string.

```
gert@ubuntu:~$ whatis route
route (8)            - show / manipulate the IP routing table
```

whereis

The location of a manpage can be revealed with **whereis**.

```
gert@ubuntu:~$ whereis passwd
passwd: /usr/bin/passwd /etc/passwd /usr/share/man/man1/passwd.1.gz
/usr/share/man/man1/passwd.1ssl.gz /usr/share/man/man5/passwd.5.gz
```

This manpage-files are directly readable by **man**.

```
gert@ubuntu:~$ man /usr/share/man/man5/passwd.5.gz
```

man sections

By now you will have noticed the numbers between the round brackets. **man man** will explain to you that these are section numbers. Executable programs and shell commands reside in section one.

```
1 Executable programs or shell commands
2 System calls (functions provided by the kernel)
3 Library calls (functions within program libraries)
4 Special files (usually found in /dev)
5 File formats and conventions eg /etc/passwd
6 Games
7 Miscellaneous (including macro packages and conventions), e.g. man(7)
8 System administration commands (usually only for root)
9 Kernel routines [Non standard]
```

man $section $file

Therefor, when referring to the man page of the passwd command, you will see it written as **passwd(1)**; when referring to the **passwd file**, you will see it written as **passwd(5)**. The screenshot explains how to open the man page in the correct section.

```
gert@ubuntu:~$ man passwd      # opens the first manual found, here man 1 passwd
gert@ubuntu:~$ man 5 passwd    # opens a page from section 5
```

man man

If you want to know more about **man**, then Read The Fantastic Manual (RTFM).
Unfortunately, manual pages do not have the answer to everything…

```
gert@ubuntu:~$ man woman
No manual entry for woman
```

mandb

Should you be convinced that a man page exists, but you can't access it, then try running **mandb** on Debian/Mint.

```
gert@ubuntu:~$ sudo mandb
0 man subdirectories contained newer manual pages.
0 manual pages were added.
0 stray cats were added.
0 old database entries were purged.
```

Searching in the man pages

You can search through a man page by typing a slash (/) followed by a string (word, letter,...)

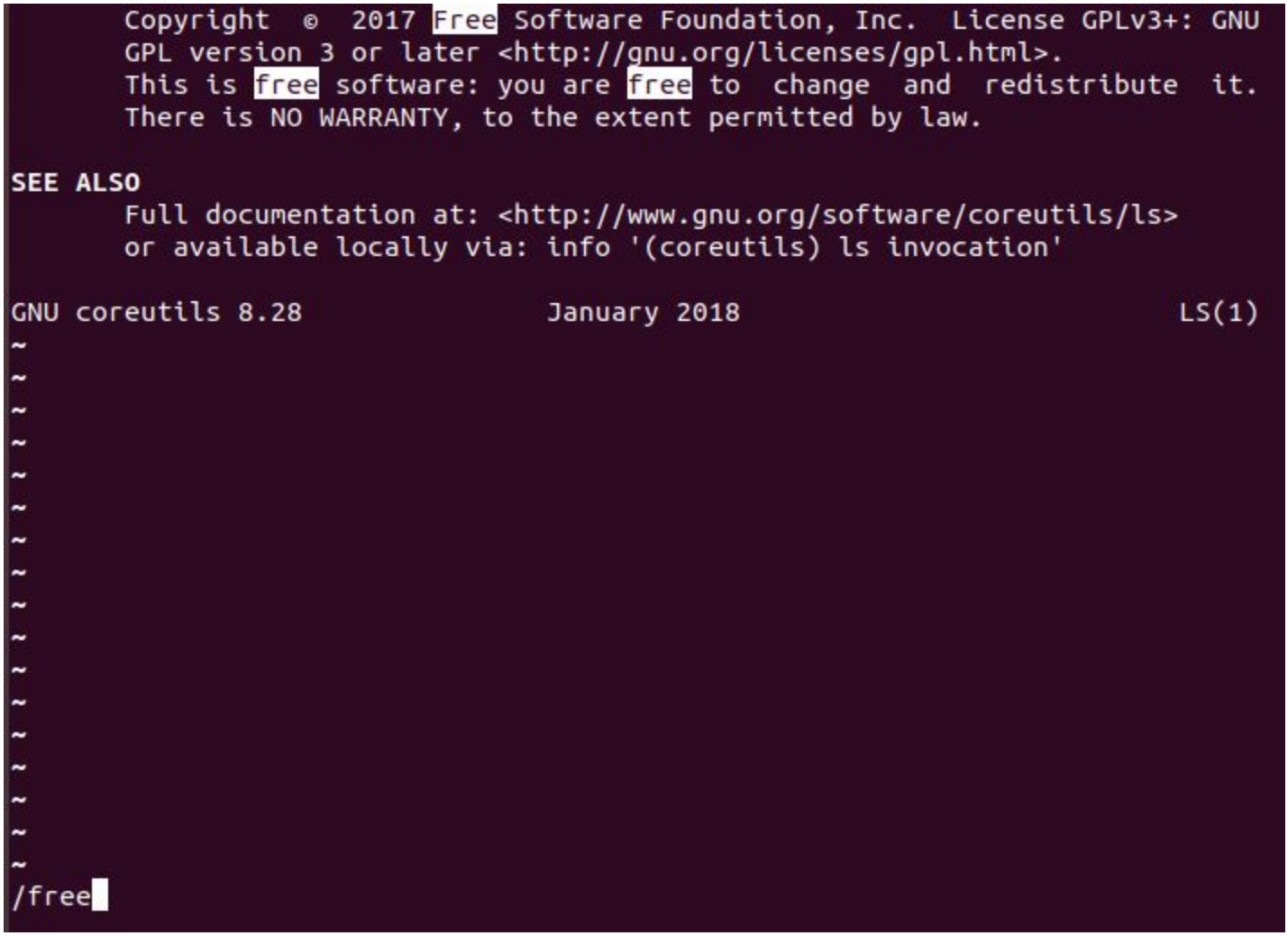
```
gert@ubuntu:~$ man ls
```

```
LS(1)                          User Commands                          LS(1)

NAME
       ls - list directory contents

SYNOPSIS
       ls [OPTION]... [FILE]...

DESCRIPTION
       List  information  about the FILEs (the current directory by default).
       Sort entries alphabetically if none of -cftuvSUX nor --sort is  speci-
       fied.

       Mandatory  arguments  to  long options are mandatory for short options
       too.

       -a, --all
              do not ignore entries starting with .

       -A, --almost-all
              do not list implied . and ..

       --author
              with -l, print the author of each file

       -b, --escape
              print C-style escapes for nongraphic characters
 Manual page ls(1) line 1 (press h for help or q to quit)
```

→ type

`/free  and push <enter>  (all lowercase)`

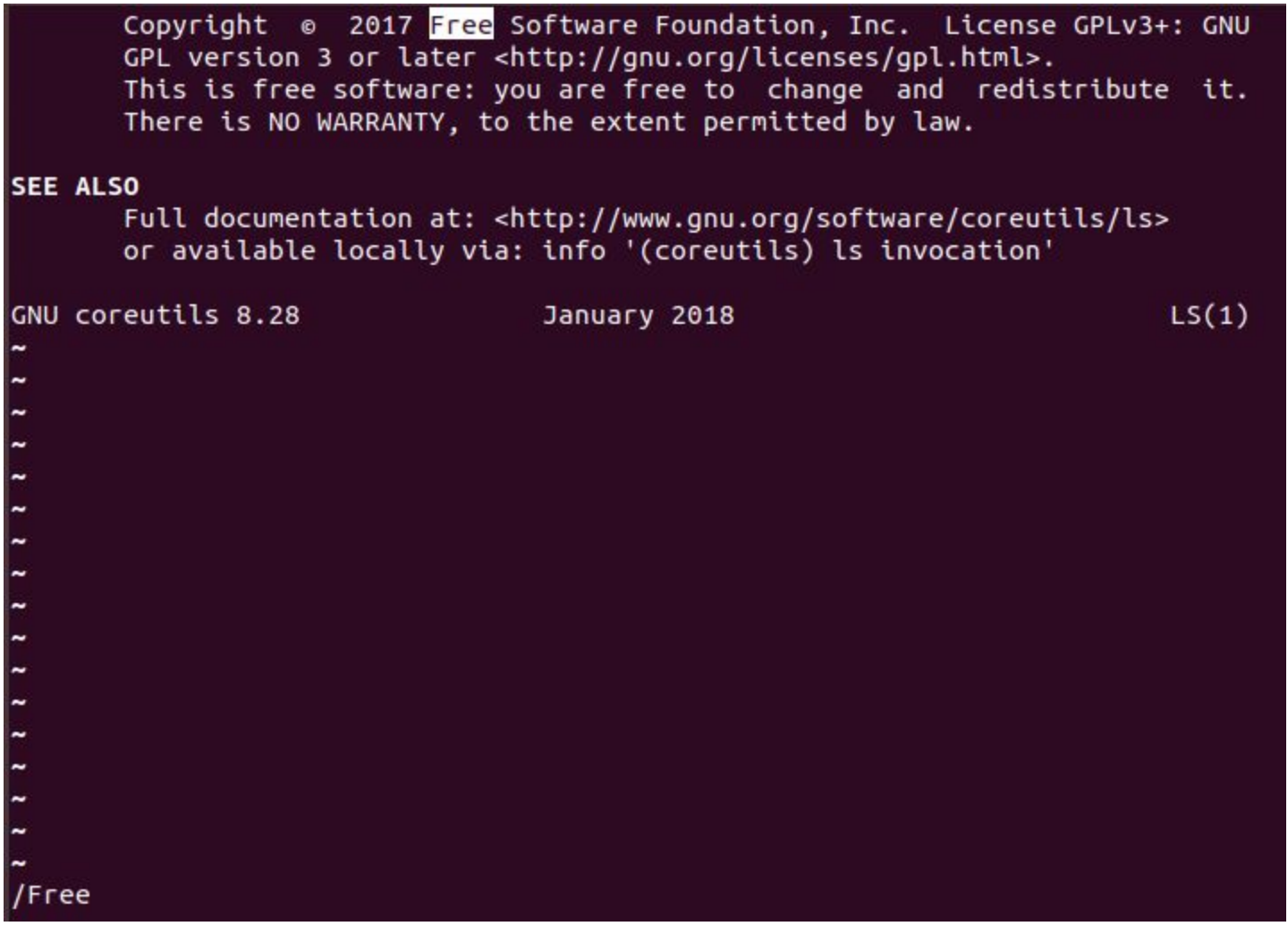
this searches **case insensitive** for all strings with the letters 'free'



→ type

`/Free  and push <enter>  (at least one uppercase letter)`

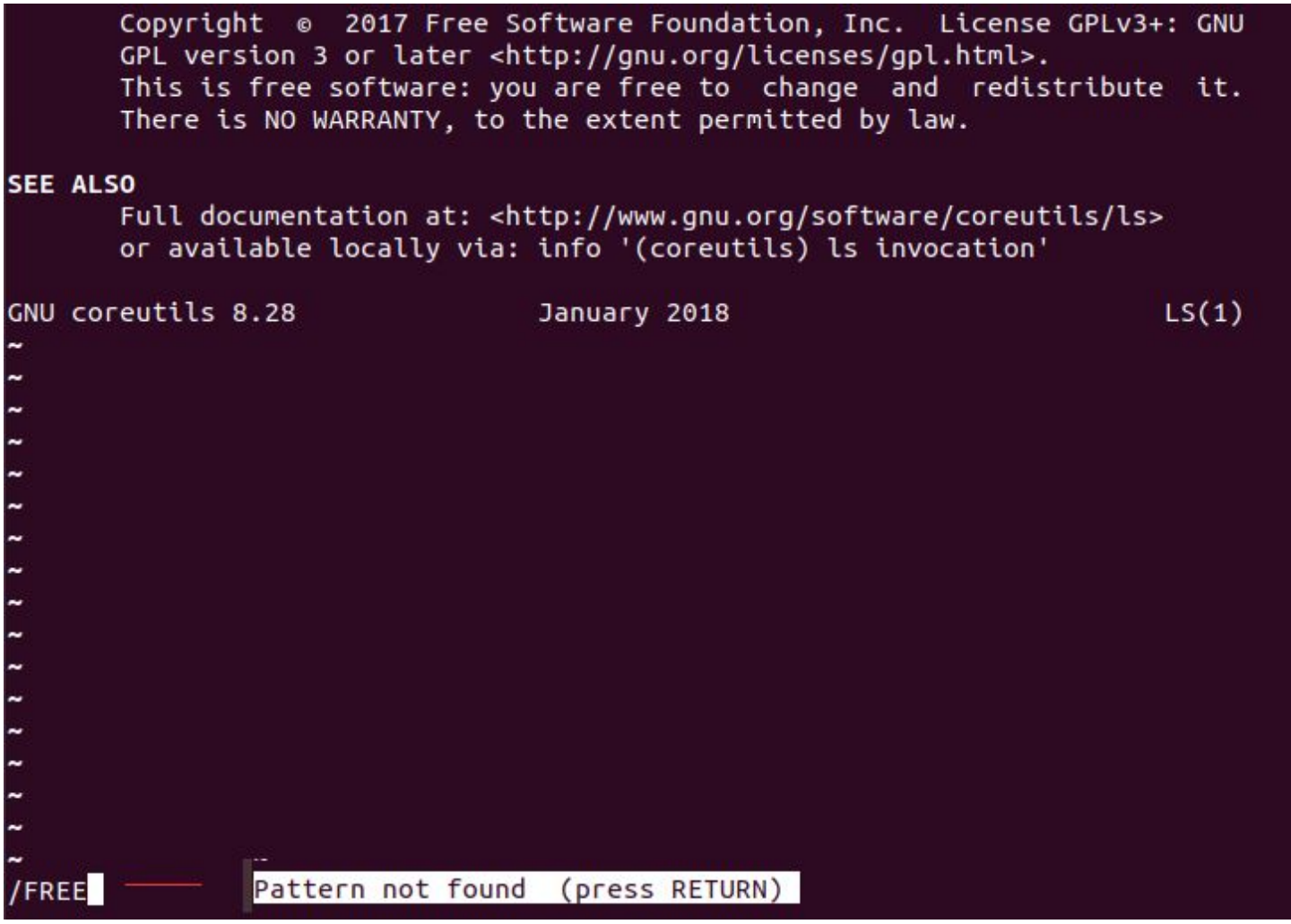
this searches **case sensitive** for all strings with the characters 'Free'



→ type

`/FREE  and push <enter>` `(at least one uppercase letter)`

this searches **case sensitive** for all strings with the characters 'FREE'



How to move between found occurences

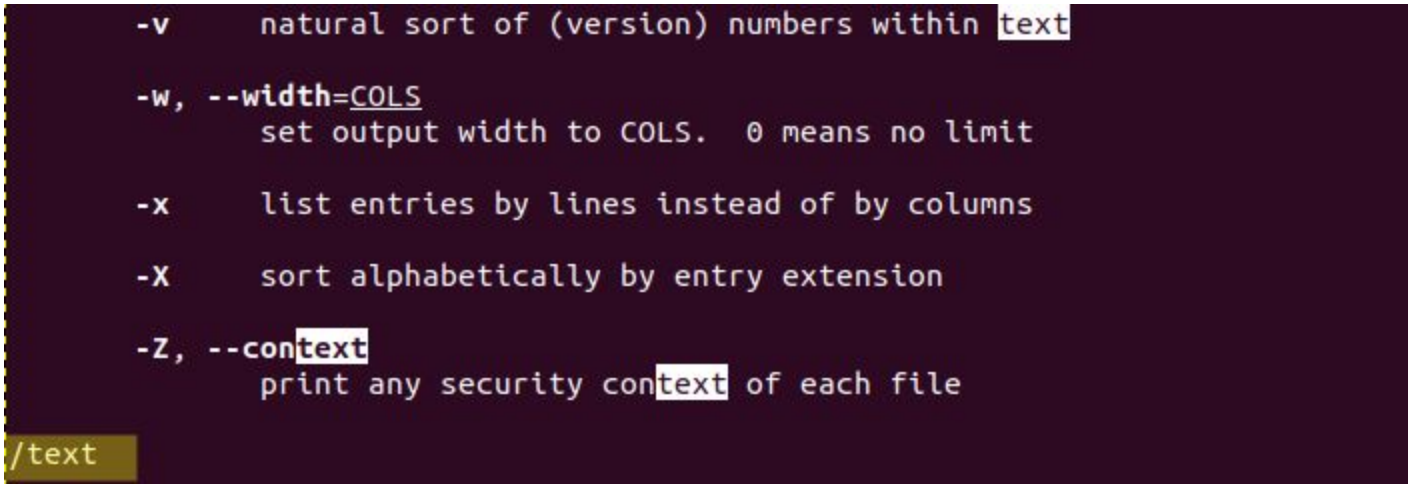
type 'n'	(lowercase)	To go to the **next** occurence
type 'N'	(uppercase)	To go to the **previous** occurence

Searching for a whole word (not a string)

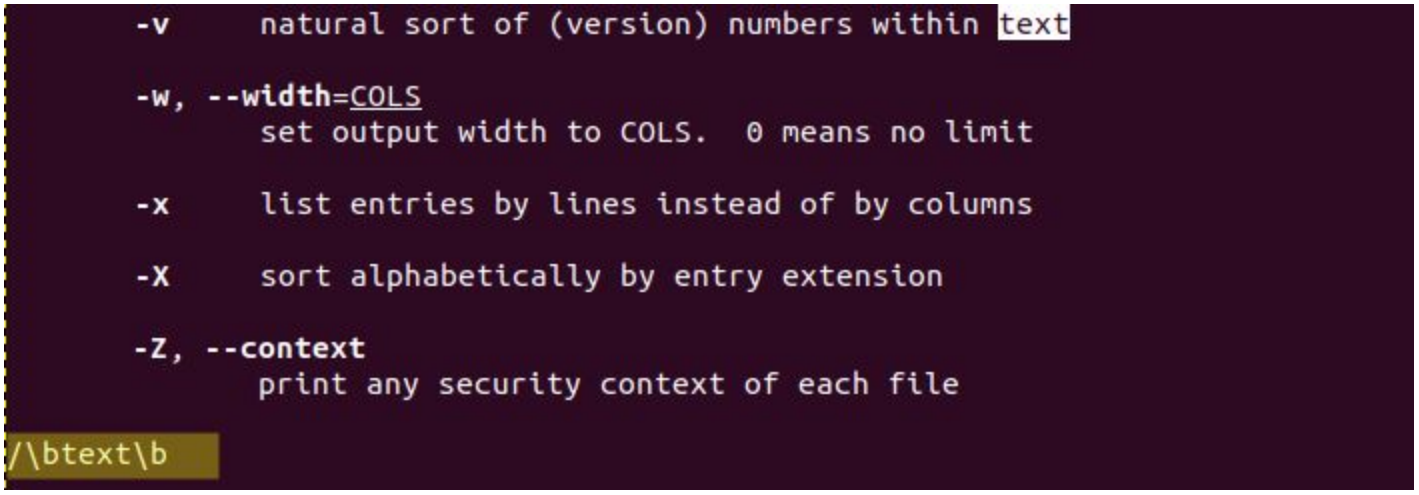
→ type

`/\btext\b` and push <enter> (\b without surrounding spaces)

this searches cases insensitive for **whole words** 'text'



VS



Remark! You cannot always use '/ text ' (spaces surrounding the string), because it is not the same.

Extra shortcuts

type 'g'	(lowercase)	To go to the **first line**
type 'G'	(uppercase)	To go to the **last line**

you can also use the **arrow keys**, the **SPACE**, and the keys **PAGEUP** and **PAGEDOWN**

type 'h'	(lowercase)	To get the **help** of man

TIP

it 's always a good idea to type 'g' (lowercase), to go to the first line, before starting a search!

Chapter 6. Working with directories

This module is a brief overview of the most common commands to work with directories: **pwd**, **cd**, **ls**, **mkdir** and **rmdir**. These commands are available on any Linux (or Unix) system.
This module also discusses **absolute** and **relative paths** and **path completion** in the **bash** shell.

pwd

The **you are here** sign can be displayed with the **pwd** command (Print Working Directory). Go ahead, try it: Open a command line interface (also called a terminal, console or xterm) and type **pwd**. The tool displays your **current directory**.

```
gert@ubuntu:~$ pwd
/home/gert
```

cd

You can change your current directory with the **cd** command (Change Directory).

```
gert@ubuntu:~$ cd /etc
gert@ubuntu:/etc$ pwd
/etc
gert@ubuntu:/etc$ cd /bin
gert@ubuntu:/bin$ pwd
/bin
gert@ubuntu:/bin$ cd /home/gert/
gert@ubuntu:~$ pwd
/home/gert
```

cd ~

The **cd** is also a shortcut to get back into your home directory. Just typing **cd** without a target directory, will put you in your home directory. Typing **cd ~** has the same effect.

```
gert@ubuntu:~$ cd /etc
gert@ubuntu:/etc$ pwd
/etc
gert@ubuntu:/etc$ cd
gert@ubuntu:~$ pwd
/home/gert
gert@ubuntu:~$ cd /etc
gert@ubuntu:/etc$ pwd
/etc
gert@ubuntu:~$ cd ~
gert@ubuntu:~$ pwd
/home/gert
```

cd ..

To go to the **parent directory** (the one just above your current directory in the directory tree), type **cd ..** .

```
gert@ubuntu:/usr/share/games$ pwd
/usr/share/games
gert@ubuntu:/usr/share/games$ cd ..
gert@ubuntu:/usr/share$ pwd
/usr/share
```

*To stay in the current directory, type **cd .** ;-)* We will see useful use of the **.** character representing the current directory later.

cd -

Another useful shortcut with **cd** is to just type **cd -** to go to the previous directory.

```
gert@ubuntu:~$ pwd
/home/gert
gert@ubuntu:~$ cd /etc
gert@ubuntu:/etc$ pwd
/etc
gert@ubuntu:/etc$ cd -
/home/gert
gert@ubuntu:~$ cd -
/etc
gert@ubuntu:/etc$
```

absolute and relative paths

You should be aware of **absolute and relative paths** in the file tree. When you type a path starting with a **slash (/)**, then the **root** of the file tree is assumed. If you don't start your path with a slash, then the current directory is the assumed starting point.
The screenshot below first shows the current directory **/home/gert**. From within this directory, you have to type **cd /home** instead of **cd home** to go to the **/home** directory.

```
gert@ubuntu:~$ pwd
/home/gert
gert@ubuntu:~$ cd home
bash: cd: home: No such file or directory
gert@ubuntu:~$ cd /home
gert@ubuntu:/home$ pwd
/home
```

When inside **/home**, you have to type **cd gert** instead of **cd /gert** to enter the subdirectory **gert** of the current directory **/home**.

```
gert@ubuntu:/home$ pwd
/home
gert@ubuntu:/home$ cd /gert
bash: cd: /gert: No such file or directory
gert@ubuntu:/home$ cd gert
gert@ubuntu:~$ pwd
/home/gert
```

In case your current directory is the **root directory /**, then both **cd /home** and **cd home** will get you in the **/home** directory.

```
gert@ubuntu:/$ pwd
/
gert@ubuntu:/$ cd home
gert@ubuntu:/home$ pwd
/home
gert@ubuntu:/home$ cd /
gert@ubuntu:/$ pwd
/
gert@ubuntu:/$ cd /home
gert@ubuntu:/home$ pwd
/home
```

This was the last screenshot with **pwd** statements. From now on, the current directory will be displayed in the prompt. Later in this book we will explain how the shell variable **$PS1** can be configured to show this.

path completion

The **tab key** can help you in typing a path without errors. Typing **cd /et** followed by the **tab key** will expand the command line to **cd /etc/**. When typing **cd /Et** followed by the **tab key**, nothing will happen because you typed the wrong **path** (upper case E).
You will need fewer key strokes when using the **tab key**, and you will be sure your typed **path** is correct!

ls

You can list the contents of a directory with **ls**.

```
gert@ubuntu:~$ ls
allfiles.txt  dmesg.txt  services   stuff  summer.txt
gert@ubuntu:~$
```

ls -a

A frequently used option with ls is **-a** to show all files. Showing all files means including the **hidden files**. When a file name on a Linux file system starts with a dot, it is considered a **hidden file** and it doesn't show up in regular file listings.

```
gert@ubuntu:~$ ls
allfiles.txt  dmesg.txt  services  stuff  summer.txt
gert@ubuntu:~$ ls -a
.   allfiles.txt   .bash_profile  dmesg.txt   .lesshst  stuff
..  .bash_history  .bashrc        services    .ssh      summer.txt
gert@ubuntu:~$
```

ls -l

Many times you will be using options with **ls** to display the contents of the directory in different formats or to display different parts of the directory. Typing just **ls** gives you a list of files in the directory. Typing **ls -l** (that is a letter L, not the number 1) gives you a long listing.

```
gert@ubuntu:~$ ls -l
total 17296
-rw-r--r-- 1 gert gert 17584442 Sep 17 00:03 allfiles.txt
-rw-r--r-- 1 gert gert    96650 Sep 17 00:03 dmesg.txt
-rw-r--r-- 1 gert gert    19558 Sep 17 00:04 services
drwxr-xr-x 2 gert gert     4096 Sep 17 00:04 stuff
-rw-r--r-- 1 gert gert        0 Sep 17 00:04 summer.txt
```

ls -lh

Another frequently used ls option is **-h**. It shows the numbers (file sizes) in a more human readable format. Also shown below is some variation in the way you can give the options to **ls**. We will explain the details of the output later in this book.

Note that we use the letter L as an option in this screenshot, not the number 1.

```
gert@ubuntu:~$ ls -l -h
total 17M
-rw-r--r-- 1 gert gert  17M Sep 17 00:03 allfiles.txt
-rw-r--r-- 1 gert gert  95K Sep 17 00:03 dmesg.txt
-rw-r--r-- 1 gert gert  20K Sep 17 00:04 services
drwxr-xr-x 2 gert gert 4.0K Sep 17 00:04 stuff
-rw-r--r-- 1 gert gert    0 Sep 17 00:04 summer.txt
gert@ubuntu:~$ ls -lh
total 17M
-rw-r--r-- 1 gert gert  17M Sep 17 00:03 allfiles.txt
-rw-r--r-- 1 gert gert  95K Sep 17 00:03 dmesg.txt
-rw-r--r-- 1 gert gert  20K Sep 17 00:04 services
drwxr-xr-x 2 gert gert 4.0K Sep 17 00:04 stuff
-rw-r--r-- 1 gert gert    0 Sep 17 00:04 summer.txt
gert@ubuntu:~$ ls -hl
total 17M
-rw-r--r-- 1 gert gert  17M Sep 17 00:03 allfiles.txt
-rw-r--r-- 1 gert gert  95K Sep 17 00:03 dmesg.txt
-rw-r--r-- 1 gert gert  20K Sep 17 00:04 services
drwxr-xr-x 2 gert gert 4.0K Sep 17 00:04 stuff
-rw-r--r-- 1 gert gert    0 Sep 17 00:04 summer.txt
gert@ubuntu:~$ ls -h -l
total 17M
-rw-r--r-- 1 gert gert  17M Sep 17 00:03 allfiles.txt
-rw-r--r-- 1 gert gert  95K Sep 17 00:03 dmesg.txt
-rw-r--r-- 1 gert gert  20K Sep 17 00:04 services
drwxr-xr-x 2 gert gert 4.0K Sep 17 00:04 stuff
-rw-r--r-- 1 gert gert    0 Sep 17 00:04 summer.txt
gert@ubuntu:~$
```

tree

To get an overview of you directories and files in the form of a tree. You have to install the package first.

```
gert@ubuntu:~$ sudo apt install tree
```

```
gert@ubuntu:~$ tree
.
├── Desktop
├── Documents
├── Downloads
├── Music
│   └── Abba
│       └── Dancing Queen.mp3
├── Pictures
├── Public
├── scripts
│   ├── ls
│   └── ls2
├── script.sh
├── Templates
└── Videos

10 directories, 4 files
```

mkdir

Walking around the Unix file tree is fun, but it is even more fun to create your own directories with **mkdir**. You have to give at least one parameter to **mkdir**, the name of the new directory to be created. Think before you type a leading */* .

```
gert@ubuntu:~$ mkdir mydir
gert@ubuntu:~$ cd mydir
gert@ubuntu:~/mydir$ ls -al
total 8
drwxr-xr-x  2 gert gert 4096 Sep 17 00:07 .
drwxr-xr-x 48 gert gert 4096 Sep 17 00:07 ..
gert@ubuntu:~/mydir$ mkdir stuff
gert@ubuntu:~/mydir$ mkdir otherstuff
gert@ubuntu:~/mydir$ ls -al
total 8
drwxr-xr-x  2 gert gert 4096 Sep 17 00:07 .
drwxr-xr-x 48 gert gert 4096 Sep 17 00:07 ..
drwxr-xr-x 2 gert gert 4096 Sep 17 00:08 otherstuff
drwxr-xr-x 2 gert gert 4096 Sep 17 00:08 stuff
gert@ubuntu:~/mydir$
```

mkdir -p

The following command will fail, because the **parent directory** of **threedirsdeep** does not exist.

```
gert@ubuntu:~$ mkdir mydir2/mysubdir2/threedirsdeep
mkdir: cannot create directory ‘mydir2/mysubdir2/threedirsdeep’: No such fi\
le or directory
```

When given the option **-p**, then **mkdir** will create **parent directories** as needed.

```
gert@ubuntu:~$ mkdir -p mydir2/mysubdir2/threedirsdeep
gert@ubuntu:~$ cd mydir2
gert@ubuntu:~/mydir2$ ls -l
total 4
drwxr-xr-x 3 gert gert 4096 Sep 17 00:11 mysubdir2
gert@ubuntu:~/mydir2$ cd mysubdir2
gert@ubuntu:~/mydir2/mysubdir2$ ls -l
total 4
drwxr-xr-x 2 gert gert 4096 Sep 17 00:11 threedirsdeep
gert@ubuntu:~/mydir2/mysubdir2$ cd threedirsdeep/
gert@ubuntu:~/mydir2/mysubdir2/threedirsdeep$ pwd
/home/gert/mydir2/mysubdir2/threedirsdeep
```

rmdir

When a directory is empty, you can use **rmdir** to remove the directory.

```
gert@ubuntu:~/mydir$ ls -l
total 8
drwxr-xr-x 2 gert gert 4096 Sep 17 00:08 otherstuff
drwxr-xr-x 2 gert gert 4096 Sep 17 00:08 stuff
gert@ubuntu:~/mydir$ rmdir otherstuff
gert@ubuntu:~/mydir$ cd ..
gert@ubuntu:~$ rmdir mydir
rmdir: failed to remove ‘mydir’: Directory not empty
gert@ubuntu:~$ rmdir mydir/stuff
gert@ubuntu:~$ rmdir mydir
gert@ubuntu:~$
```

rmdir -p

And similar to the **mkdir -p** option, you can also use **rmdir** to recursively remove directories if they don't contain any files.

```
gert@ubuntu:~$ mkdir -p test42/subdir
gert@ubuntu:~$ rmdir -p test42/subdir
gert@ubuntu:~$
```

Chapter 7. Working with files

In this chapter we learn how to recognise, create, remove, copy and move files using commands like **file, touch, rm, cp, mv** and **rename**.

all files are case sensitive

Files on Linux (or any Unix) are **case sensitive**. This means that **FILE1** is different from **file1**, and **/etc/hosts** is different from **/etc/Hosts** (the latter one does not exist on a typical Linux computer).
This screenshot shows the difference between two files, one with upper case **W**, the other with lower case **w**.

```
gert@ubuntu:~/Linux$ ls
winter.txt  Winter.txt
gert@ubuntu:~/Linux$ cat winter.txt
It is cold.
gert@ubuntu:~/Linux$ cat Winter.txt
It is very cold!
```

everything is a file

A **directory** is a special kind of **file**, but it is still a (case sensitive!) **file**. Each terminal window (for example **/dev/pts/4**), any hard disk or partition (for example **/dev/sdb1**) and any process are all represented somewhere in the **file system** as a **file**. It will become clear throughout this course that everything on Linux is a **file**.

file

The **file** utility determines the file type. Linux does not use extensions to determine the file type. The command line does not care whether a file ends in .txt or .pdf. As a system administrator, you should use the **file** command to determine the file type. Here are some examples on a typical Linux system.

```
gert@ubuntu:~$ file pic33.png
pic33.png: PNG image data, 3840 x 1200, 8-bit/color RGBA, non-interlaced
gert@ubuntu:~$ file /etc/passwd
/etc/passwd: ASCII text
gert@ubuntu:~$ file HelloWorld.c
HelloWorld.c: C source, ASCII C program text
```

The file command uses a magic file that contains patterns to recognise file types. The magic file is located in **/usr/share/file/magic**. Type **man 5 magic** for more information.
It is interesting to point out **file -s** for special files like those in **/dev** and **/proc**.

```
root@ubuntu~# file /dev/sda
/dev/sda: block special
root@ubuntu~# file -s /dev/sda
/dev/sda: x86 boot sector; partition 1: ID=0x83, active, starthead...
root@ubuntu~# file /proc/cpuinfo
/proc/cpuinfo: empty
root@ubuntu~# file -s /proc/cpuinfo
/proc/cpuinfo: ASCII text, with very long lines
```

touch

create an empty file

One easy way to create an empty file is with **touch**. (We will see many other ways for creating files later in this book.)
This screenshot starts with an empty directory, creates two files with **touch** and the lists those files.

```
gert@ubuntu:~$ ls -l
total 0
gert@ubuntu:~$ touch file42
gert@ubuntu:~$ touch file33
gert@ubuntu:~$ ls -l
total 0
-rw-r--r-- 1 gert gert 0 Oct 15 08:57 file33
-rw-r--r-- 1 gert gert 0 Oct 15 08:56 file42
gert@ubuntu:~$
```

touch -t

The **touch** command can set some properties while creating empty files. Can you determine what is set by looking at the next example? If not, check the manual for **touch**.

```
gert@ubuntu:~$ touch -t 201905050000 biology
gert@ubuntu:~$ touch -t 143105301330 history.txt
gert@ubuntu:~$ ls -l
total 0
-rw-r--r-- 1 gert gert 0 May  5  2019 biology
-rw-r--r-- 1 gert gert 0 Oct 15 08:57 file33
-rw-r--r-- 1 gert gert 0 Oct 15 08:56 file42
-rw-r--r-- 1 gert gert 0 May 30  1431 history.txt
gert@ubuntu:~$
```

Pay Attention! The timestamp shows the **year** if the file is **older than six months**, otherwise the **time** is shown.

rm

remove forever

When you no longer need a file, use **rm** to remove it. Unlike some graphical user interfaces, the command line in general does not have a **waste bin** or **trash can** to recover files. When you use **rm** to remove a file, the file is gone. Therefore, be careful when removing files!

```
gert@ubuntu:~$ ls
history.txt  file33  file42  biology
gert@ubuntu:~$ rm history.txt
gert@ubuntu:~$ ls
file33  file42  biology
gert@ubuntu:~$
```

rm -i

To prevent yourself from accidentally removing a file, you can type **rm -i**.

```
gert@ubuntu:~$ ls
biology file33  file42
gert@ubuntu:~$ rm -i file33
rm: remove regular empty file `file33'? yes
gert@ubuntu:~$ rm -i biology
rm: remove regular empty file `biology'? n
gert@ubuntu:~$ ls
biology file42
gert@ubuntu:~$
```

`rm .*`

Removing hidden files. By default the shell option dotglob is unset. This means that, **by default, 'rm *' will only delete** files that do not start with a dot (**hidden files**).
WARNING: Do not try these commands in your homefolder! It will remove necessary files!
If you want to delete hidden files you have **two options:**

```
Option 1:
gert@ubuntu:~$ mkdir demo
gert@ubuntu:~$ cd demo
gert@ubuntu:~/demo$ touch .hiddenfile1 .hiddenfile2 visiblefile1  visiblefile2
gert@ubuntu:~/demo$ ls -A
.hiddenfile1 .hiddenfile2 visiblefile1  visiblefile2
gert@ubuntu:~/demo$ rm *
gert@ubuntu:~/demo$ ls -A
.hiddenfile1 .hiddenfile2
gert@ubuntu:~/demo$ rm .*
rm: cannot remove '.': Is a directory
rm: cannot remove '..': Is a directory
gert@ubuntu:~/demo$ ls -A
gert@ubuntu:~/demo$ cd
gert@ubuntu:~$ rmdir demo
```

```
Option 2:
gert@ubuntu:~$ mkdir demo
gert@ubuntu:~$ cd demo
gert@ubuntu:~/demo$ touch .hiddenfile1 .hiddenfile2 visiblefile1  visiblefile2
gert@ubuntu:~/demo$ ls -A
.hiddenfile1 .hiddenfile2 visiblefile1  visiblefile2
gert@ubuntu:~/demo$ shopt -s dotglob
gert@ubuntu:~/demo$ rm *
gert@ubuntu:~/demo$ ls -A
gert@ubuntu:~/demo$ shopt -u dotglob
gert@ubuntu:~/demo$ cd
gert@ubuntu:~$ rmdir demo
```

Instead of specifying the two commands 'rm *' and 'rm .*' , you could also do it **in one command** with **rm {*,.*}**

rm -rf

By default, **rm -r** will not remove non-empty directories. However **rm** accepts several options that will allow you to remove any directory. The **rm -rf** statement is famous because it will erase anything (providing that you have the permissions to do so). When you are logged on as root, be very careful with **rm -rf** (the **f** means **force** and the **r** means **recursive**) since being root implies that permissions don't apply to you. You can literally erase your entire file system by accident.

```
gert@ubuntu:~$ mkdir test
gert@ubuntu:~$ touch test/file55
gert@ubuntu:~$ ls
biology file42 test
gert@ubuntu:~$ ls test
file55
gert@ubuntu:~$ rm test
rm: cannot remove 'test': Is a directory
gert@ubuntu:~$ rmdir test
rmdir: failed to remove 'test': Directory not empty
gert@ubuntu:~$ rm -rf test
gert@ubuntu:~$ ls
biology file42
gert@ubuntu:~$
```

cp

copy one file

To copy a file, use **cp** with a source and a target argument.

```
gert@ubuntu:~$ ls
file42  biology
gert@ubuntu:~$ cp file42 file42.copy
gert@ubuntu:~$ ls
file42  file42.copy  biology
```

copy to another directory

If the target is a directory, then the source files are copied to that target directory.

```
gert@ubuntu:~$ ls
file42  biology
gert@ubuntu:~$ mkdir dir42
gert@ubuntu:~$ cp biology dir42/
gert@ubuntu:~$ ls dir42/
biology
```

cp -r

To copy complete directories, use **cp -r** (the **-r** option forces **recursive** copying of all files in all subdirectories).

```
gert@ubuntu:~$ ls
dir42  file42  file42.copy  biology
gert@ubuntu:~$ ls /dir42
biology
gert@ubuntu:~$ cp -r dir42/ dir33
gert@ubuntu:~$ ls
dir33  dir42  file42  file42.copy  biology
gert@ubuntu:~$ ls dir33/
biology
```

copy multiple files to directory

You can also use cp to copy multiple files into a directory. In this case, the last argument (a.k.a. the target) must be a directory.

```
gert@ubuntu:~$ cp file42 file42.copy biology dir42/
gert@ubuntu:~$ ls dir42/
file42  file42.copy  biology
```

rename a file while copying to another directory

You can also rename a file while it is being copied. Just specify a new name in the last argument of the cp command..

```
gert@ubuntu:~$ cp file42 dir42/file42.backup
gert@ubuntu:~$ ls dir42/
file42  file42.backup file42.copy  biology
```

cp -i

To prevent **cp** from overwriting existing files, use the **-i** (for interactive) option.

```
gert@ubuntu:~$ cp biology file42
gert@ubuntu:~$ cp biology file42
gert@ubuntu:~$ cp -i biology file42
cp: overwrite `file42'? n
gert@ubuntu:~$
```

mv

move or rename files with mv

Use **mv** to rename a file or to move the file to another directory.

```
gert@ubuntu:~$ ls
dir33  dir42  file42  file42.copy  biology
gert@ubuntu:~$ mv file42 file33
gert@ubuntu:~$ ls
dir33  dir42  file33  file42.copy  biology
gert@ubuntu:~$
gert@ubuntu:~$ mv file33 dir42/
gert@ubuntu:~$ ls
dir33  dir42  file42.copy  biology
gert@ubuntu:~$ ls dir42/
file33  file42  file42.copy  biology
```

When you need to rename only one file then **mv** is the preferred command to use.

rename directories with mv

The same **mv** command can be used to rename directories.

```
gert@ubuntu:~$ ls -l
total 8
drwxr-xr-x 2 gert gert 4096 Oct 15 09:36 dir33
drwxr-xr-x 2 gert gert 4096 Oct 15 09:36 dir42
-rw-r--r-- 1 gert gert    0 Oct 15 09:38 file33
-rw-r--r-- 1 gert gert    0 Oct 15 09:16 file42.copy
-rw-r--r-- 1 gert gert    0 May  5  2005 biology
gert@ubuntu:~$ mv dir33 backup
gert@ubuntu:~$ ls -l
total 8
drwxr-xr-x 2 gert gert 4096 Oct 15 09:36 backup
drwxr-xr-x 2 gert gert 4096 Oct 15 09:36 dir42
-rw-r--r-- 1 gert gert    0 Oct 15 09:38 file33
-rw-r--r-- 1 gert gert    0 Oct 15 09:16 file42.copy
-rw-r--r-- 1 gert gert    0 May  5  2005 biology
gert@ubuntu:~$
```

mv -i

The **mv** also has a **-i** switch similar to **cp** and **rm**.
this screenshot shows that **mv -i** will ask permission to overwrite an existing file.

```
gert@ubuntu:~$ mv -i file33 biology
mv: overwrite `biology'? no
gert@ubuntu:~$
```

rename

about rename

The **rename** command is one of the rare occasions where the Linux Fundamentals book has to make a distinction between Linux distributions. Almost every command in the **Fundamentals** part of this book works on almost every Linux computer. But **rename** is different.
Try to use **mv** whenever you need to rename only a couple of files.

rename on Debian/Ubuntu

The **rename** command on the Debian-family distributions uses regular expressions (regular expression or shor regex are explained in a later chapter) to rename many files at once.
Below a **rename** example that switches all occurrences of txt to png for all file names ending in .txt.

```
gert@ubuntu:~/test42$ ls
abc.txt  file33.txt  file42.txt anotherfile.docx
gert@ubuntu:~/test42$ rename 's/\txt/\png/' *.txt
gert@ubuntu:~/test42$ ls
abc.png  file33.png  file42.png  anotherfile.docx
```

This second example switches all (first) occurrences of **file** into **document** for all file names ending in .png.

```
gert@ubuntu:~/test42$ ls
abc.png  file33.png  file42.png  anotherfile.docx
gert@ubuntu:~/test42$ rename 's/file/document/' *
gert@ubuntu:~/test42$ ls
abc.png  document33.png  document42.png  anotherdocument.docx
gert@ubuntu:~/test42$
```

Chapter 8. Working with file contents

In this chapter we will look at the contents of **text files** with **head, tail, cat, tac, more, less** and **strings**. We will also get a glimpse of the possibilities of tools like **cat** on the command line.

head

You can use **head** to display the first ten lines of a file.

```
gert@ubuntu~$ head /etc/passwd
root:x:0:0:root:/root:/bin/bash
daemon:x:1:1:daemon:/usr/sbin:/bin/sh
bin:x:2:2:bin:/bin:/bin/sh
sys:x:3:3:sys:/dev:/bin/sh
sync:x:4:65534:sync:/bin:/bin/sync
games:x:5:60:games:/usr/games:/bin/sh
man:x:6:12:man:/var/cache/man:/bin/sh
lp:x:7:7:lp:/var/spool/lpd:/bin/sh
mail:x:8:8:mail:/var/mail:/bin/sh
news:x:9:9:news:/var/spool/news:/bin/sh
gert@ubuntu~#
```

The **head** command can also display the first **n** lines of a file.

```
gert@ubuntu~$ head -4 /etc/passwd
root:x:0:0:root:/root:/bin/bash
daemon:x:1:1:daemon:/usr/sbin:/bin/sh
bin:x:2:2:bin:/bin:/bin/sh
sys:x:3:3:sys:/dev:/bin/sh
gert@ubuntu~$
```

And **head** can also display the first **n bytes**.

```
gert@ubuntu~$ head -c14 /etc/passwd
root:x:0:0:roogert@ubuntu~$
```

tail

Similar to **head**, the **tail** command will display the last ten lines of a file.

```
gert@ubuntu~$ tail /etc/services
vboxd           20012/udp
binkp           24554/tcp                       # binkp fidonet protocol
asp             27374/tcp                       # Address Search Protocol
asp             27374/udp
csync2          30865/tcp                       # cluster synchronization tool
dircproxy       57000/tcp                       # Detachable IRC Proxy
tfido           60177/tcp                       # fidonet EMSI over telnet
fido            60179/tcp                       # fidonet EMSI over TCP

# Local services
gert@ubuntu~$
```

You can give **tail** the number of lines you want to see.

```
gert@ubuntu~$ tail -3 /etc/services
fido            60179/tcp                       # fidonet EMSI over TCP

# Local services
gert@ubuntu~$
```

The **tail** command has other useful options, some of which we will use during this course.

cat

The **cat** command is one of the most universal tools, yet all it does is copy **standard input** to **standard output**. In combination with the shell this can be very powerful and diverse. Some examples will give a glimpse into the possibilities. The first example is simple, you can use cat to display a file on the screen. If the file is longer than the screen, it will scroll to the end.

```
gert@ubuntu:~$ cat /etc/resolv.conf
domain linux-training.be
search linux-training.be
nameserver 192.168.1.42
```

concatenate

cat is short for **concatenate**. One of the basic uses of **cat** is to concatenate files into a bigger (or complete) file.

```
gert@ubuntu:~$ echo one > part1
gert@ubuntu:~$ echo two > part2
gert@ubuntu:~$ echo three > part3
gert@ubuntu:~$ cat part1
one
gert@ubuntu:~$ cat part2
two
gert@ubuntu:~$ cat part3
three
gert@ubuntu:~$ cat part1 part2 part3
one
two
three
gert@ubuntu:~$ cat part1 part2 part3 > all
gert@ubuntu:~$ cat all
one
two
three
gert@ubuntu:~$
```

create files

You can use **cat** to create flat text files. Type the **cat > winter.txt** command as shown in the screenshot below. Then type one or more lines, finishing each line with the enter key. After the last line, type and hold the **Control** (Ctrl) key and press **d**.

```
gert@ubuntu:~$ cat > winter.txt
It is very cold today!                    CTRL+d
gert@ubuntu:~$ cat winter.txt
It is very cold today!
gert@ubuntu:~$
```

The **Ctrl d** key combination will send an **EOF** (End of File) to the running process ending the **cat** command.

custom end marker

You can choose an end marker for **cat** with **<<** as is shown in this screenshot. This construction is called a **here documents** and will end the **cat** command. Attention: the word you specify cannot have any spaces on the left or right.

```
gert@ubuntu:~$ cat > hot.txt <<stop
> It is hot today!
> Yes it is summer.
> stop
gert@ubuntu:~$ cat hot.txt
It is hot today!
Yes it is summer.
gert@ubuntu:~$
```

copy files

You can use cat to copy a fle. We will explain in detail what happens here in the I/O redirection chapter.

```
gert@ubuntu:~$ cat winter.txt
It is very cold today!
gert@ubuntu:~$ cat winter.txt > cold.txt
gert@ubuntu:~$ cat cold.txt
It is very cold today!
gert@ubuntu:~$
```

tac

Just one example will show you the purpose of **tac** (cat backwards).

```
gert@ubuntu:~$ cat count
one
two
three
four
gert@ubuntu:~$ tac count
four
three
two
one
```

more and less

The **more** command is useful for displaying files that take up more than one screen. More will allow you to see the contents of the file page by page. Use the space bar to see the next page, or **q** to quit. Some people prefer the **less** command to **more**, because you can go up in the document with the UP arrow or PAGEUP key.

strings

With the **strings** command you can display readable ascii strings found in (binary) files. This example locates the **ls** binary then displays readable strings in the binary file (output is truncated).

```
gert@ubuntu:~$ which ls
/bin/ls
gert@ubuntu:~$ strings /bin/ls
/lib/ld-linux.so.2
librt.so.1
__gmon_start__
_Jv_RegisterClasses
clock_gettime
libacl.so.1
…
List information about the FILEs (the current directory by default).
Sort entries alphabetically if none of -cftuvSUX nor --sort is specified.
Mandatory arguments to long options are mandatory for short options too.
  -a, --all                  do not ignore entries starting with .
  -A, --almost-all           do not list implied . and ..
      --author               with -l, print the author of each file
…
```

Chapter 9. the Linux file tree

This chapter takes a look at the most common directories in the **Linux file tree**. It also shows that on Unix **everything is a file**.

filesystem hierarchy standard

Many Linux distributions partially follow the **Filesystem Hierarchy Standard.** The FHS may help make more Unix/Linux file system trees conform better in the future. The FHS is available online at **http://www.pathname.com/fhs/** where we read: "The filesystem hierarchy standard has been designed to be used by Unix distribution developers, package developers, and system implementers. However, it is primarily intended to be a reference and is not a tutorial on how to manage a Unix filesystem or directory hierarchy."

man hier

There are some differences in the filesystems between Linux distributions. For help about your machine, enter **man hier** to find information about the file system hierarchy. This manual will **explain** the **directory structure** on your computer.

the root directory (/)

All Linux systems have a directory structure that starts at the **root directory.** The root directory is represented by a **forward slash**, like this: /. Everything that exists on your Linux system can be found below this root directory. Let's take a brief look at the contents of the root directory.

```
gert@ubuntu~$ ls /
bin    dev   lib    libx32      mnt   root  snap      sys  var
boot   etc   lib32  lost+found  opt   run   srv       tmp
cdrom  home  lib64  media       proc  sbin  swapfile  usr
```

/boot

The **/boot** directory contains all files needed to boot the computer. These files don't change very often.
On Linux systems you typically find the **/boot/grub** directory here. /boot/grub contains **/boot/grub/grub.cfg** which defines the boot menu that is displayed before the kernel starts.

```
gert@ubuntu~$ ls /boot
config-5.4.0-48-generic      memtest86+.elf
config-5.4.0-51-generic      memtest86+_multiboot.bin
efi                          System.map-5.4.0-48-generic
grub                         System.map-5.4.0-51-generic
initrd.img                   vmlinuz
initrd.img-5.4.0-48-generic  vmlinuz-5.4.0-48-generic
initrd.img-5.4.0-51-generic  vmlinuz-5.4.0-51-generic
initrd.img.old               vmlinuz.old
```

```
gert@ubuntu~$ ls /boot/grub/
fonts  gfxblacklist.txt  grub.cfg  grubenv  i386-pc  unicode.pf2
```

/bin

Binaries are files that contain compiled source code (or machine code). Binaries can be executed on the computer. Sometimes binaries are called **executables**.
The /**bin** directory contains **binaries for** use by **all users**.
In the screenshot below you see common Unix/Linux commands like cat, cp, and so on.

```
gert@ubuntu~$ ls /bin
/bin/cal                        /bin/chvt
/bin/calendar                   /bin/ciptool
/bin/calibrate_ppa              /bin/ckbcomp
/bin/canberra-gtk-play          /bin/cksum
/bin/cancel                     /bin/clear
/bin/captoinfo                  /bin/clear_console
/bin/cat                        /bin/cmp
/bin/catchsegv                  /bin/codepage
/bin/catman                     /bin/col
/bin/cautious-launcher          /bin/colcrt
/bin/cd-create-profile          /bin/colormgr
/bin/cd-fix-profile             /bin/colrm
/bin/cd-iccdump                 /bin/column
/bin/cd-it8                     /bin/comm
/bin/c++filt                    /bin/compose
/bin/chacl                      /bin/corelist
/bin/chage                      /bin/cp
...
```

You can find a /bin subdirectory in many other directories. A user named serena could put her own programs in /home/serena/bin. Some applications, often when installed directly from source will put themselves in /opt. A samba server installation can use /opt/samba/bin to store its binaries.

/sbin

/sbin contains binaries to configure the operating system. Many of the **system binaries require root privileges** to perform certain tasks.
Below a screenshot containing system binaries to add a user, partition a disk
and create an file system.

```
gert@ubuntu:~$ ls -l /sbin/useradd /sbin/fdisk /sbin/mkfs
-rwxr-xr-x 1 root root 153880 jul 21 09:49 /sbin/fdisk
-rwxr-xr-x 1 root root  14568 jul 21 09:49 /sbin/mkfs
-rwxr-xr-x 1 root root 147160 mei 28 08:37 /sbin/useradd
```

/etc

All of the machine-specific **configuration files** should be located in **/etc**. Historically /etc stood for etcetera, today people often use the Editable Text Configuration backronym. Many times the name of a configuration files is the same as the application, daemon, or protocol with .conf added as the extension.

```
gert@ubuntu:~$ ls /etc/*.conf
/etc/adduser.conf           /etc/host.conf        /etc/pnm2ppa.conf
/etc/apg.conf               /etc/kernel-img.conf  /etc/popularity-contest.conf
/etc/appstream.conf         /etc/kerneloops.conf  /etc/resolv.conf
/etc/brltty.conf            /etc/ld.so.conf       /etc/rsyslog.conf
/etc/ca-certificates.conf   /etc/libao.conf       /etc/rygel.conf
/etc/debconf.conf           /etc/libaudit.conf    /etc/sensors3.conf
/etc/deluser.conf           /etc/logrotate.conf   /etc/sysctl.conf
/etc/e2scrub.conf           /etc/ltrace.conf      /etc/ucf.conf
/etc/fprintd.conf           /etc/mke2fs.conf      /etc/usb_modeswitch.conf
/etc/fuse.conf              /etc/mtools.conf      /etc/xattr.conf
/etc/gai.conf               /etc/nsswitch.conf
/etc/hdparm.conf            /etc/pam.conf
```

/etc/skel

The **skeleton** directory **/etc/skel** is copied to the home directory of a newly created user. It usually contains hidden files like a **.bashrc** script

```
gert@ubuntu:~$ ls -A /etc/skel/
.bash_logout  .bashrc  .profile
```

/etc/sysconfig

This directory, which is not mentioned in the FHS, contains a lot of **Red Hat Enterprise Linux** configuration files.

```
gert@ubuntu:~$ ls /etc/sysconfig
anaconda         firewalld         libvirtd         raid-check   smartmontools
atd              grub              man-db           rhn          snapd
cbq              ip6tables-config  modules          rpcbind      sshd
chronyd          iptables-config   network          rsyslog      virtlockd
console          irqbalance        network-scripts  run-parts    virtlogd
cpupower         kdump             nftables.conf    samba        wpa_supplicant
crond            kernel            qemu-ga          saslauthd
ebtables-config  ksm               radvd            selinux
```

/home

Users can store personal or project data under **/home**. It is common (but not mandatory by the fhs) practice to name the users home directory after the user name in the format **/home/ $USERNAME**.

```
gert@ubuntu:~$ ls /home
gert
```

Besides giving every user (or every project or group) a location to store personal files, the home directory of a user also serves as a location to store the user **profile**. A typical Unix user profile contains many **hidden files** (files whose file name starts with a dot). The hidden files of the Unix user profiles contain **settings specific for that user**.

```
gert@ubuntu:~$ ls -a /home/gert
.              .cache     .gnupg            Pictures  .sudo_as_admin_successful
..             .config    .lesshst          .profile  Templates
.bash_history  Desktop    .local            Public    Videos
.bash_logout   Documents  Music             snap
.bashrc        Downloads  .pam_environment  .ssh
```

/root

On many systems **/root** is the default location for **personal data and profile of the root user**.

```
gert@ubuntu:~$ sudo ls -A /root
.bashrc  .cache  .profile
```

/srv

You may use **/srv** for **data that is served** by your system. The FHS allows locating cvs, rsync, ftp and www data in this location. The FHS also approves administrative naming in /srv, like /srv/project55/ftp and /srv/sales/www.
Webserver-data is **often** not saved in srv but **saved in /var/www**.

/lib

Binaries found in /bin and /sbin often use **shared libraries** located in **/lib**. Below is a screenshot of the partial contents of /lib.

```
gert@ubuntu:~$ ls /lib
accountsservice                 linux-sound-base
apg                             locale
apparmor                        lp_solve
apt                             lsb
aspell                          man-db
binfmt.d                        memtest86+
bluetooth                       mime
bolt                            modprobe.d
brltty                          modules
cnf-update-db                   modules-load.d
command-not-found               netplan
...
```

/media

The **/media** directory serves as a mount point for **removable media devices** such as USB-sticks, CDROM's, digital cameras, and various usb-attached devices. Most Linux distributions today mount all removable media in /media.

```
gert@ubuntu:~$ ls /media/gert/Ubuntu\ 20.04.1\ LTS\ amd64/
boot    dists  install   md5sum.txt  pool     README.diskdefines
casper  EFI    isolinux  pics        preseed  ubuntu
```

/mnt

The **/mnt** directory should be empty and should only be used for **temporary mount points** (according to the FHS). Unix and Linux administrators used to create many directories here, like /mnt/something/.
You likely will encounter many systems with more than one directory created and/or mounted inside /mnt to be used for various local and **remote filesystems**.

/opt

The purpose of **/opt** is to store **optional** software. In many cases this is software from outside the distribution repository. You may find an empty /opt directory on many systems.
A large package can install all its files in **/bin, /lib, /etc** subdirectories within **/opt/$packagename/**. If for example the package is called **wp**, then it installs in **/opt/wp**, putting binaries in **/opt/wp/bin** and manpages in **/opt/wp/man**.

```
gert@ubuntu:~$ ls /opt/VBoxGuestAdditions-6.1.10/
bin  init  installer  LICENSE  other  routines.sh  sbin  src  uninstall.sh
```

/tmp

Applications and users should use **/tmp** to store **temporary data** when needed. Data stored in /tmp may use either disk space or RAM. Both of which are managed by the operating system. Never use /tmp to store data that is important or which you wish to archive. In some distributions the /tmp directory is **cleaned at every boot** in some other distributions every file in /tmp is **deleted if older than 10 days**.

```
gert@ubuntu:~$ cat /usr/lib/tmpfiles.d/tmp.conf
#  This file is part of systemd.
#
#  systemd is free software; you can redistribute it and/or modify it
#  under the terms of the GNU Lesser General Public License as published by
#  the Free Software Foundation; either version 2.1 of the License, or
#  (at your option) any later version.
#
# See tmpfiles.d(5) for details
#
# Clear tmp directories separately, to make them easier to override
D /tmp 1777 root root -
#q /var/tmp 1777 root root 30d
```

/dev

Device files in **/dev** appear to be ordinary files, but are not actually located on the hard disk.
The /dev directory is **populated** with files as the **kernel** is **recognising** hardware **devices**.
(Common hardware such as hard disk devices, cd-roms, usb-sticks, terminals or consoles, etc)

```
gert@ubuntu:~$ ls -d /dev/[stp]??
/dev/ppp  /dev/sda  /dev/sg1  /dev/snd  /dev/tty
/dev/pts  /dev/sg0  /dev/shm  /dev/sr0
```

/dev/null

On Linux you will find other special devices such as **/dev/null** which can be considered a black hole; it has unlimited storage, but nothing can be retrieved from it. Technically speaking, anything written to /dev/null will be discarded. /dev/null can be useful to **discard unwanted output** from commands.

```
gert@ubuntu:~$ echo Hello World > /dev/null
gert@ubuntu:~$
```

/proc

/proc is another special directory, appearing to be ordinary files, but not taking up any disk space. It is actually **a view of the kernel**, or better, what the kernel manages, and is a means to interact with it directly. /proc is a proc filesystem. **When you ask for a file, the kernel will add it's data realtime to the file.** So, you're talking to the kernel via these files.

```
gert@ubuntu:~$ cat /proc/meminfo
MemTotal:        4002248 kB
MemFree:         1935876 kB
MemAvailable:    2793476 kB
Buffers:           81892 kB
Cached:           934376 kB
```

/sys

Basically the **/sys** directory contains **kernel information** about the **system.**
The /proc filesystem maps mostly to the process table. People found this very useful, and started adding other things to it as well - cpuinfo, memory statistics, device information… but it also raised the issue that /proc was SUPPOSED to be for the process table… So they added another instance, and named it “sys” aimed to hold system information. But being newer, the entries already added to /proc were allowed to remain as moving them would cause issues with other user tools that processed those files.

```
gert@ubuntu:~$ cat /sys/block/sda/sda5/size
40888320
```

/usr

Although **/usr** is pronounced like user, remember that it stands for **Unix System Resources**. The /usr hierarchy should contain **shareable, read only data**. Sometimes it is mounted as read only.

```
gert@ubuntu:~$ ls /usr/bin/apt*
/usr/bin/apt                    /usr/bin/apt-ftparchive
/usr/bin/apt-add-repository     /usr/bin/apt-get
/usr/bin/apt-cache              /usr/bin/apt-key
/usr/bin/apt-cdrom              /usr/bin/apt-mark
/usr/bin/apt-config             /usr/bin/apt-sortpkgs
/usr/bin/aptdcon                /usr/bin/apturl
/usr/bin/apt-extracttemplates   /usr/bin/apturl-gtk
```

/var/www

On some distros the **website data** is saved in **/var/www** instead of /srv.

```
gert@ubuntu:~$ ls /var/www/html
index.html
```

/var/log

The **/var/log** directory serves as a central point to contain all **log files.**

```
gert@ubuntu:~$ ls /var/log/
alternatives.log  dmesg            installer          ubuntu-advantage.log
apt               dmesg.0          journal            unattended-upgrades
auth.log          dmesg.1.gz       kern.log           vmware-network.1.log
auth.log.1        dmesg.2.gz       kern.log.1         vmware-network.log
auth.log.2.gz     dmesg.3.gz       kern.log.2.gz      vmware-vmsvc-root.1.log
boot.log          dmesg.4.gz       lastlog            vmware-vmsvc-root.2.log
boot.log.1        dpkg.log         openvpn            vmware-vmsvc-root.3.log
boot.log.2        faillog          private            vmware-vmsvc-root.log
bootstrap.log     fontconfig.log   speech-dispatcher  vmware-vmtoolsd-root.log
btmp              gdm3             syslog             wtmp
cups              gpu-manager.log  syslog.1
dist-upgrade      hp               syslog.2.gz
```

/var/log/syslog

A typical first file to check when **troubleshooting** on Debian derivatives like **Ubuntu** is the **/var/log/syslog** file. By default this file will contain information on what just happened to the system. It is the file **where** (almost) **every service will log to**.

```
gert@ubuntu:~$ grep dhcp4 /var/log/syslog
Oct 18 00:01:46 ubdesk NetworkManager[750]: <info>  [1602972106.1005] dhcp4
(ens33): canceled DHCP transaction
Oct 18 00:01:46 ubdesk NetworkManager[750]: <info>  [1602972106.1005] dhcp4
(ens33): state changed extended -> done
Oct 18 00:01:46 ubdesk NetworkManager[750]: <info>  [1602972106.1035] dhcp4
(ens33): activation: beginning transaction (timeout in 45 seconds)
Oct 18 00:01:46 ubdesk NetworkManager[750]: <info>  [1602972106.1134] dhcp4
(ens33): option dhcp_lease_time      => '1800'
Oct 18 00:01:46 ubdesk NetworkManager[750]: <info>  [1602972106.1135] dhcp4
(ens33): option domain_name          => 'localdomain'
Oct 18 00:01:46 ubdesk NetworkManager[750]: <info>  [1602972106.1135] dhcp4
(ens33): option domain_name_servers  => '172.16.201.2'
Oct 18 00:01:46 ubdesk NetworkManager[750]: <info>  [1602972106.1135] dhcp4
(ens33): option expiry               => '1602973906'
Oct 18 00:01:46 ubdesk NetworkManager[750]: <info>  [1602972106.1135] dhcp4
(ens33): option ip_address           => '172.16.201.150'
...
```

/var/log/messages

A typical first file to check when **troubleshooting on Red Hat** (and derivatives) is the **/var/log/messages** file. By default this file will contain information on what just happened to the system. It is the file **where** (almost) **every service will log to**. The file is called /var/log/syslog on Debian and Ubuntu.

```
gert@ubuntu:~$ sudo grep dhcp4 /var/log/messages
Oct 15 16:26:53 centos NetworkManager[1085]: <info>  [1602772013.6580] dhcp4
(enp0s3): activation: beginning transaction (timeout in 45 seconds)
Oct 15 16:26:53 centos NetworkManager[1085]: <info>  [1602772013.6996] dhcp4
(enp0s3): option dhcp_lease_time      => '86400'
Oct 15 16:26:53 centos NetworkManager[1085]: <info>  [1602772013.6996] dhcp4
(enp0s3): option domain_name          => 'home'
Oct 15 16:26:53 centos NetworkManager[1085]: <info>  [1602772013.6997] dhcp4
(enp0s3): option domain_name_servers  => '10.0.2.3'
Oct 15 16:26:53 centos NetworkManager[1085]: <info>  [1602772013.6997] dhcp4
(enp0s3): option expiry               => '1602858413'
Oct 15 16:26:53 centos NetworkManager[1085]: <info>  [1602772013.6997] dhcp4
(enp0s3): option ip_address           => '10.0.2.15'
...
```

Chapter 10. Commands and arguments

This chapter introduces you to **shell expansion** by taking a close look at **commands** and **arguments**. Knowing **shell expansion** is important because many **commands** on your Linux system are processed and most likely changed by the **shell** before they are executed.
The command line interface or **shell** used on most Linux systems is called **bash**, which stands for **Bourne again shell**. The **bash** shell incorporates features from **sh** (the original Bourne shell), **csh** (the C shell), and **ksh** (the Korn shell).
This chapter frequently uses the **echo** command to demonstrate shell features. The **echo** command is very simple: it echoes the input that it receives.

```
gert@ubuntu:~$ echo Burtonville
Burtonville
gert@ubuntu:~$ echo Smurfs are blue
Smurfs are blue
```

arguments

One of the primary features of a shell is to perform a **command line scan**. When you enter a command at the shell's command prompt and press the enter key, then the shell will start scanning that line, cutting it up in **arguments**. While scanning the line, the shell may make many changes to the **arguments** you typed.
This process is called **shell expansion**. When the shell has finished scanning and modifying that line, then it will be executed.

white space removal

Parts that are separated by one or more consecutive **white spaces** (or tabs) are considered separate **arguments**, any white space is removed. The first **argument** is the command to be executed, the other **arguments** are given to the command. The shell effectively cuts your command into one or more arguments. This explains why the following four different command lines are the same after **shell expansion**.

```
gert@ubuntu:~$ echo Hello World
Hello World
gert@ubuntu:~$ echo Hello   World
Hello World
gert@ubuntu:~$ echo   Hello   World
Hello World
gert@ubuntu:~$    echo      Hello      World
Hello World
```

The **echo** command will display each argument it receives from the shell. The **echo** command will also add a new white space between the arguments it received.

single quotes

You can prevent the removal of white spaces by quoting the spaces. The contents of the quoted string are considered as one argument. In the screenshot below the **echo** receives only one **argument**.

```
gert@ubuntu:~$ echo 'A line with      single    quotes'
A line with      single    quotes
gert@ubuntu:~$
```

double quotes

You can also prevent the removal of white spaces by double quoting the spaces. Same as above, **echo** only receives one **argument**.

```
gert@ubuntu:~$ echo "A line with      double    quotes"
A line with      double    quotes
gert@ubuntu:~$
```

Later in this book, when discussing **variables** we will see important differences between single and double quotes.

echo and quotes

Quoted lines can include special escaped characters recognised by the **echo** command (when using **echo -e**). The screenshot below shows how to use **\n** for a newline and **\t** for a tab (usually eight white spaces).

```
gert@ubuntu:~$ echo -e "A line with \na newline"
A line with
a newline
gert@ubuntu:~$ echo -e 'A line with \na newline'
A line with
a newline
gert@ubuntu:~$ echo -e "A line with \ta tab"
A line with     a tab
gert@ubuntu:~$ echo -e 'A line with \ta tab'
A line with     a tab
gert@ubuntu:~$
```

The echo command can generate more than white spaces, tabs and newlines. Look in the man page for a list of options.

commands

`external or builtin commands ?`

Not all commands are external to the shell, some are **builtin**. **External commands** are programs that have their own binary and reside somewhere in the file system. Many external commands are located in **/bin** or **/sbin**. **Builtin commands** are an integral part of the shell program itself.

`type`

To find out whether a command given to the shell will be executed as an **external command** or as a **builtin command**, use the **type** command.

```
gert@ubuntu:~$ type cd
cd is a shell builtin
gert@ubuntu:~$ type cat
cat is /bin/cat
```

As you can see, the **cd** command is **builtin** and the **cat** command is **external**.
You can also use this command to show you whether the command is **aliased** or not.

```
gert@ubuntu:~$ type ls
ls is aliased to `ls --color=auto'
```

`running external commands`

Some commands have both builtin and external versions. When one of these commands is executed, the builtin version takes priority. To run the external version, you must enter the full path to the command.

```
gert@ubuntu:~$ type -a echo
echo is a shell builtin
echo is /bin/echo
gert@ubuntu:~$ /bin/echo Running the external echo command...
Running the external echo command...
```

`which`

The **which** command will search for binaries in the **$PATH** environment variable (variables will be explained later). In the screenshot below, it is determined that **cd** is **builtin** (shows no output), and **ls, cp, rm, mv, mkdir, pwd,** and **which** are external commands.

```
gert@ubuntu:~$ which cp ls cd mkdir pwd
/bin/cp
/bin/ls
/bin/mkdir
/bin/pwd
```

aliases

create an alias

The shell allows you to create **aliases**. Aliases are often used to create an easier to remember name for an existing command or to easily supply parameters.

```
gert@ubuntu:~$ cat count.txt
one
two
three
gert@ubuntu:~$ alias dog=tac
gert@ubuntu:~$ dog count.txt
three
two
one
```

abbreviate commands

An **alias** can also be useful to abbreviate an existing command.

```
gert@ubuntu:~$ alias ll='ls -lh --color=auto'
gert@ubuntu:~$ alias c='clear'
gert@ubuntu:~$
```

default options

Aliases can be used to supply commands with default options. The example below shows how to set the **-i** option default when typing **rm**.

```
gert@ubuntu:~$ rm -i winter.txt
rm: remove regular file `winter.txt'? no
gert@ubuntu:~$ rm winter.txt
gert@ubuntu:~$ ls winter.txt
ls: winter.txt: No such file or directory
gert@ubuntu:~$ touch winter.txt
gert@ubuntu:~$ alias rm='rm -i'
gert@ubuntu:~$ rm winter.txt
rm: remove regular empty file `winter.txt'? no
gert@ubuntu:~$
```

Some distributions enable default aliases to protect users from accidentally erasing files ('rm -i', 'mv -i', 'cp -i')

viewing aliases

You can provide one or more aliases as arguments to the **alias** command to get their definitions. Providing no arguments gives a complete list of current aliases.

```
gert@ubuntu:~$ alias c ll
alias c='clear'
alias ll='ls -lh --color=auto'
```

`unalias`

You can undo an alias with the **unalias** command.

```
gert@ubuntu:~$ which rm
/bin/rm
gert@ubuntu:~$ alias rm='rm -i'
gert@ubuntu:~$ which rm
/bin/rm
gert@ubuntu:~$ type rm
rm is aliased to `rm -i'
gert@ubuntu:~$ unalias rm
gert@ubuntu:~$ which rm
/bin/rm
gert@ubuntu:~$
```

Chapter 11. Control operators

In this chapter we put more than one command on the command line using **control operators**. We also briefly discuss related parameters ($?) and similar special characters(&).

; semicolon

You can put two or more commands on the same line separated by a semicolon **;** . The shell will scan the line until it reaches the semicolon. All the arguments before this semicolon will be considered a separate command from all the arguments after the semicolon. Both series will be executed sequentially with the shell waiting for each command to finish before starting the next one.

```
gert@ubuntu:~$ echo Hello
Hello
gert@ubuntu:~$ echo World
World
gert@ubuntu:~$ echo Hello ; echo World
Hello
World
gert@ubuntu:~$
```

& ampersand

When a line ends with an ampersand &, the shell will not wait for the command to finish. You will get your shell prompt back, and the command is executed in background. You will get a message when this command has finished executing in background.

```
gert@ubuntu:~$ sleep 20 &
[1] 7925
gert@ubuntu:~$
...wait 20 seconds...
gert@ubuntu:~$
[1]+  Done                    sleep 20
```

The technical explanation of what happens in this case is explained in the chapter about processes.

$? dollar question mark

The exit code of the previous command is stored in the shell variable **$?**. Actually **$?** is a shell parameter and not a variable, since you cannot assign a value to **$?**.

```
gert@ubuntu:~/test$ touch file1
gert@ubuntu:~/test$ echo $?
0
gert@ubuntu:~/test$ rm file1
gert@ubuntu:~/test$ echo $?
0
gert@ubuntu:~/test$ rm file1
rm: cannot remove `file1': No such file or directory
gert@ubuntu:~/test$ echo $?
1
gert@ubuntu:~/test$
```

&& double ampersand

The shell will interpret **&&** as a **logical AND**. When using **&&** the second command is executed only if the first one succeeds (returns a zero exit status).

```
gert@ubuntu:~$ echo first && echo second
first
second
gert@ubuntu:~$ zecho first && echo second
-bash: zecho: command not found
```

Another example of the same **logical AND** principle. This example starts with a working **cd** followed by **ls**, then a non-working **cd** which is **not** followed by **ls**.

```
gert@ubuntu:~$ cd gen && ls
file1  file3  File55  fileab  FileAB   fileabc
file2  File4  FileA   Fileab  fileab2
gert@ubuntu:~/gen$ cd gen && ls
-bash: cd: gen: No such file or directory
```

|| double vertical bar

The **||** represents a **logical OR**. The second command is executed only when the first command fails (returns a non-zero exit status).

```
gert@ubuntu:~$ echo first || echo second ; echo third
first
third
gert@ubuntu:~$ zecho first || echo second ; echo third
-bash: zecho: command not found
second
third
gert@ubuntu:~$
```

Another example of the same **logical OR** principle.

```
gert@ubuntu:~$ cd gen || ls
gert@ubuntu:~/gen$ cd gen || ls
-bash: cd: gen: No such file or directory
file1  file3  File55  fileab  FileAB   fileabc
file2  File4  FileA   Fileab  fileab2
```

combining && and ||

You can use this logical AND and logical OR to write an **if-then-else** structure on the command line. This example uses **echo** to display whether the **rm** command was successful.

```
gert@ubuntu:~/test$ rm file1 && echo It worked! || echo It failed!
It worked!
gert@ubuntu:~/test$ rm file1 && echo It worked! || echo It failed!
rm: cannot remove `file1': No such file or directory
It failed!
gert@ubuntu:~/test$
```

pound sign

Everything written after a **pound sign** (#) is ignored by the shell. This is useful to write a **shell comment**, but has no influence on the command execution or shell expansion.

```
gert@ubuntu:~$ cat .bash_logout
# ~/.bash_logout: executed by bash(1) when login shell exits.
# when leaving the console clear the screen to increase privacy
if [ "$SHLVL" = 1 ]; then   # SHLVL holds the current shell level (shell-nesting)
    [ -x /usr/bin/clear_console ] && /usr/bin/clear_console -q
fi
gert@ubuntu:~$
```

\ escaping special characters

The backslash **** character enables the use of control characters, but without the shell interpreting it, this is called **escaping** characters.

```
gert@ubuntu:~$ echo hello \; world
hello ; world
gert@ubuntu:~$ echo hello\ \ \ world
hello   world
gert@ubuntu:~$ echo escaping \\\ \#\ \&\ \"\ \'
escaping \ # & " '
gert@ubuntu:~$ echo escaping \\\?\*\"\'
escaping \?*"'
```

end of line backslash

Lines ending in a backslash are continued on the next line. The shell does not interpret the newline character and will wait on shell expansion and execution of the command line until a newline without backslash is encountered.

```
gert@ubuntu:~$ echo This command line \
> is split in three \
> parts
This command line is split in three parts
gert@ubuntu:~$
```

Or used in a file for visibility.

```
gert@ubuntu:~/bin$ cat makecertificate.sh
# We create a new keypair for ssl on our webserver
openssl req -new -newkey -rsa 1024 -days 365 -nodes \
   -out /etc/ssl/cert/webmail.pem \
   -keyout /etc/ssl/private/webmail.key
gert@ubuntu:~/bin$
```

Chapter 12. Shell variables

In this chapter we learn to manage environment **variables** in the shell. These **variables** are often needed by applications.

$ dollar sign

Another important character interpreted by the shell is the dollar sign **$**. The shell will look for an **environment variable** named like the string following the **dollar sign** and replace it with the value of the variable (or with nothing if the variable does not exist).
These are some examples using $HOSTNAME, $USER, $UID, $SHELL, and $HOME.

```
gert@ubuntu:~$ echo This is the $SHELL shell
This is the /bin/bash shell
gert@ubuntu:~$ echo This is $SHELL on computer $HOSTNAME
This is /bin/bash on computer ubuntu
gert@ubuntu:~$ echo The userid of $USER is $UID
The userid of gert is 1000
gert@ubuntu:~$ echo My homedir is $HOME
My homedir is /home/gert
```

case sensitive

This example shows that shell variables are case sensitive!

```
gert@ubuntu:~$ echo Hello $USER
Hello gert
gert@ubuntu:~$ echo Hello $user
Hello
```

creating variables

This example creates the variable **MyVar** and sets its value. It then uses **echo** to verify the value. Be aware that it is not allowed to type spaces around the equal sign!

```
gert@ubuntu:~$ MyVar=555
gert@ubuntu:~$ echo $MyVar
555
gert@ubuntu:~$
```

quotes

Notice that double quotes still allow the parsing of variables, whereas single quotes prevent this.

```
gert@ubuntu:~$ MyVar=555
gert@ubuntu:~$ echo $MyVar
555
gert@ubuntu:~$ echo "$MyVar"
555
gert@ubuntu:~$ echo '$MyVar'
$MyVar
```

The bash shell will replace variables with their value in double quoted lines, but not in single quoted lines.

```
gert@ubuntu:~$ city=Burtonville
gert@ubuntu:~$ echo "We are in $city today."
We are in Burtonville today.
gert@ubuntu:~$ echo 'We are in $city today.'
We are in $city today.
```

set

You can use the **set** command to display a list of environment variables. On Ubuntu and Debian systems, the **set** command will also list shell functions after the shell variables. Use **set | less** to see the variables then.

unset

Use the **unset** command to remove a variable from your shell environment.

```
gert@ubuntu:~$ MyVar=8472
gert@ubuntu:~$ echo $MyVar
8472
gert@ubuntu:~$ unset MyVar
gert@ubuntu:~$ echo $MyVar

gert@ubuntu:~$
```

$PS1

The **$PS1** variable determines your shell prompt. You can use backslash escaped special characters like **\u** for the username or **\w** for the working directory. The **bash** manual has a complete reference.
In this example we change the value of **$PS1** a couple of times.

```
gert@ubuntu:~$ PS1=prompt
prompt
promptPS1='prompt '
prompt
prompt PS1='> '
>
> PS1='\u@\h$ '
gert@ubuntu$
gert@ubuntu$ PS1='\u@\h:\W$'
gert@ubuntu:~$
```

To avoid unrecoverable mistakes, you can set normal user prompts to green and the root prompt to red. Add the following to your **.bashrc** for a green user prompt with a blue working directory:

```
# color prompt
RED='\[\033[01;31m\]'
WHITE='\[\033[01;00m\]'
GREEN='\[\033[01;32m\]'
BLUE='\[\033[01;34m\]'
PS1="$GREEN\u@\h$WHITE:$BLUE\w$WHITE\$ "
```

$PATH

The **$PATH** variable is determines where the shell is looking for commands to execute (unless the command is builtin or aliased). This variable contains a list of directories, separated by colons.

```
gert@ubuntu:~$ echo $PATH
/usr/kerberos/bin:/usr/local/bin:/bin:/usr/bin:
```

The shell will not look in the current directory for commands to execute! (Looking for executables in the current directory provided an easy way to hack PC-DOS computers). If you want the shell to look in the current directory, then add a . at the end of your $PATH.

```
gert@ubuntu:~$ PATH=$PATH:.
gert@ubuntu:~$ echo $PATH
/usr/kerberos/bin:/usr/local/bin:/bin:/usr/bin:.
gert@ubuntu:~$
```

Your path might be different when using su instead of **su -** because the latter will take on the environment of the target user. The root user typically has **/sbin** directories added to the $PATH variable.

```
gert@ubuntu:~$ echo $PATH
/usr/local/bin:/bin:/usr/bin:.
gert@ubuntu:~$ sudo su
[sudo] password for gert:
root@ubuntu:~#  echo $PATH
/usr/local/bin:/bin:/usr/bin:.
root@ubuntu:~# exit
gert@ubuntu:~$ sudo su -
[sudo] password for gert:
root@ubuntu:~# echo $PATH
/usr/local/sbin:/usr/local/bin:/sbin:/bin:/usr/sbin:/usr/bin:
root@ubuntu:~#
```

env

The **env** command without options will display a list of **exported variables**. The difference with **set** with options is that **set** lists all variables, including those not exported to child shells.
But **env** can also be used to start a clean shell (a shell without any inherited environment). The **env -i** command clears the environment for the subshell.
Notice in this screenshot that **bash** will set the **$SHELL** variable on startup.

```
gert@ubuntu:~$ bash -c 'echo $SHELL $HOME $USER'
/bin/bash /home/gert gert
gert@ubuntu:~$ env -i bash -c 'echo $SHELL $HOME $USER'
/bin/bash
gert@ubuntu:~$
```

You can use the **env** command to set the **$LANG**, or any other, variable for just one instance of **bash** with one command. The example below uses this to show the influence of the **$LANG** variable on file globbing (see the chapter on file globbing).

```
gert@ubuntu:~$ ls
Filea  FileA  Fileb  FileB filea
gert@ubuntu:~$ env LANG=C bash -c 'ls File[a-z]'
Filea  Fileb
gert@ubuntu:~$ env LANG=en_US.UTF-8 bash -c 'ls File[a-z]'
Filea  FileA  Fileb  FileB
gert@ubuntu:~$
```

export

You can export shell variables to other shells with the **export** command. This will export the variable to child shells.

```
gert@ubuntu:~$ var3=three
gert@ubuntu:~$ var4=four
gert@ubuntu:~$ export var4
gert@ubuntu:~$ echo $var3 $var4
three four
gert@ubuntu:~$ bash
gert@ubuntu:~$ echo $var3 $var4
four
```

But it will not export to the parent shell (previous screenshot continued).

```
gert@ubuntu:~$ export var5=five
gert@ubuntu:~$ echo $var3 $var4 $var5
four five
gert@ubuntu:~$ exit
exit
gert@ubuntu:~$ echo $var3 $var4 $var5
three four
gert@ubuntu:~$
```

delineate variables

Until now, we have seen that bash interprets a variable starting from a dollar sign, continuing until the first occurrence of a non-alphanumeric character that is not an underscore. In some situations, this can be a problem. This issue can be resolved with curly braces like in this example.

```
gert@ubuntu:~$ prefix=Super
gert@ubuntu:~$ echo Hello $prefixman and $prefixgirl
Hello  and
gert@ubuntu:~$ echo Hello ${prefix}man and ${prefix}girl
Hello Superman and Supergirl
gert@ubuntu:~$
```

unbound variables

The example below tries to display the value of the **MyVar** variable, but it fails because the variable does not exist. By default the shell will display **nothing** when a variable is unbound (does not exist).

```
gert@ubuntu:~$ echo $MyVar

gert@ubuntu:~$
```

There is, however, the **nounset** shell option that you can use to generate an error when a variable does not exist.

```
gert@ubuntu:~$ set -u
gert@ubuntu:~$ echo $Myvar
bash: Myvar: unbound variable
gert@ubuntu:~$ set +u
gert@ubuntu:~$ echo $Myvar

gert@ubuntu:~$
```

In the bash shell **set -u** is identical to **set -o nounset** and likewise **set +u** is identical to **set +o nounset**.

Chapter 13. Shell embedding and options

This chapter takes a brief look at **child shells or sub shells**, **embedded shells** and **shell options**.

shell embedding

Shells can be **embedded** on the command line, or in other words, the command line scan can spawn new processes containing a fork of the current shell. You can use variables to prove that new shells are created.

```
gert@ubuntu:~$ date
do okt 12 14:51:52 CEST 2017

gert@ubuntu:~$ date +%A
donderdag

gert@ubuntu:~$ echo Het is vandaag date +%A
Het is vandaag date +%A

gert@ubuntu:~$ echo Het is vandaag $(date +%A)
Het is vandaag donderdag

gert@ubuntu:~$
```

You can embed a shell in an **embedded shell**, this is called **nested embedding** of shells.
This screenshot shows an embedded shell inside an embedded shell.

```
gert@ubuntu:~$ A=shell
gert@ubuntu:~$ echo $C$B$A $(B=sub;echo $C$B$A; echo $(C=sub;echo $C$B$A))
shell subshell subsubshell
```

backticks

The screenshot below uses **backticks** instead of dollar-bracket to embed.

```
gert@ubuntu:~$ echo Het is vandaag `date +%A`
Het is vandaag donderdag

gert@ubuntu:~$
```

You can only use the **$()** notation to nest embedded shells, **backticks** cannot do this.

backticks or single quotes

Placing the embedding between **backticks** uses one character less than the dollar and parenthesis combo. Be careful however, backticks are often confused with single quotes. The technical difference between **'** and **`** is significant!

```
gert@ubuntu:~$ echo Het is vandaag `date +%A`
Het is vandaag donderdag
gert@ubuntu:~$ echo Het is vandaag 'date +%A'
Het is vandaag date +%A
gert@ubuntu:~$
```

shell options

Both **set** and **unset** are builtin shell commands. They can be used to set options of the bash shell itself. The next example will clarify this. By default, the shell will treat unset variables as a variable having no value. By setting the -u option, the shell will treat any reference to unset variables as an error. See the man page of bash for more information.

```
gert@ubuntu:~$ echo $var123

gert@ubuntu:~$ set -u
gert@ubuntu:~$ echo $var123
-bash: var123: unbound variable
gert@ubuntu:~$ set +u
gert@ubuntu:~$ echo $var123

gert@ubuntu:~$
```

To list all the set options for your shell, use **echo $-**. The **noclobber** (or **-C**) option will be explained later in this book (in the I/O redirection chapter).

```
gert@ubuntu:~$ echo $-
himBH
gert@ubuntu:~$ set -C ; set -u
gert@ubuntu:~$ echo $-
himuBCH
gert@ubuntu:~$ set +C ; set +u
gert@ubuntu:~$ echo $-
himBH
gert@ubuntu:~$
```

When typing **set** without options, you get a list of all variables without function when the shell is on **posix** mode. You can set bash in posix mode typing **set -o posix**.

Chapter 14. Shell history

The shell makes it easy for us to repeat commands, this chapter explains how.

repeating the last command

To repeat the last command in bash, type **!!**. This is pronounced as **bang bang**.

```
gert@ubuntu:~$ ls /var/log/apt/
history.log  history.log.1.gz  term.log  term.log.1.gz
gert@ubuntu:~$ !!
ls /var/log/apt/
history.log  history.log.1.gz  term.log  term.log.1.gz
gert@ubuntu:~$ ls -a /root/
ls: cannot open directory '/root/': Permission denied
gert@ubuntu:~$ sudo !!
[sudo] password for student:
sudo ls -a /root/
.  ..  .bash_history  .bashrc  .cache  .gnupg  .profile
gert@ubuntu:~$
```

repeating other commands

You can repeat other commands using one **bang** followed by one or more characters. The shell will repeat the last command that started with those characters.

```
gert@ubuntu:~$ touch file42
gert@ubuntu:~$ cat file42
gert@ubuntu:~$ !to
touch file42
gert@ubuntu:~$
```

history

To see older commands, use **history** to display the shell command history (or use **history n** to see the last n commands).

```
gert@ubuntu:~/test$ history 13
38  mkdir test
39  cd test
40  touch file1
41  echo hello > file2
42  echo It is very cold today > winter.txt
43  ls
44  ls -l
45  sudo apt install tree
46  ls -l
47  touch file42
48  cat file42
49  touch file42
50  history 13
```

!n

When typing **!** followed by the number preceding the command you want repeated, then the shell will echo the command and execute it.

```
gert@ubuntu:~/test$ !43
ls
file1  file2  summer.txt  winter.txt
```

Ctrl-r

Another option is to use **ctrl-r** to search in the history. In the screenshot below i only typed **ctrl-r** followed by three characters **apt** and it finds the last command containing these three consecutive characters.
You can push ctrl-r again to keep searching throughout the history.

```
gert@ubuntu:~$   <press ctrl-r>
(reverse-i-search)`apt': sudo apt install tree                <type apt>
```

$HISTSIZE

The $HISTSIZE variable determines the number of commands that will be remembered in your current environment. Most distributions default this variable to 500 or 1000.

```
gert@ubuntu:~$ echo $HISTSIZE
1000
```

You can change it to any value you like.

```
gert@ubuntu:~$ HISTSIZE=15000
gert@ubuntu:~$ echo $HISTSIZE
15000
```

$HISTFILE

The $HISTFILE variable points to the file that contains your history. The **bash** shell defaults this value to **~/.bash_history**.

```
gert@ubuntu:~$ echo $HISTFILE
/home/gert/.bash_history
```

A session history is saved to this file when you **exit** the session!

$HISTFILESIZE

The number of commands kept in your history file can be set using $HISTFILESIZE.

```
gert@ubuntu:~$ echo $HISTFILESIZE
2000
```

prevent recording a command

You can prevent a command from being recorded in **history** using a **space** prefix.

```
gert@ubuntu:~$ echo abc
abc
gert@ubuntu:~$  echo def
def
gert@ubuntu:~$ echo ghi
ghi
gert@ubuntu:~$ history 3
 9501  echo abc
 9502  echo ghi
 9503  history 3
```

regular expressions

It is possible to use **regular expressions** when using the **bang** to repeat commands. The command below switches 1 into 2.

```
gert@ubuntu:~/test$ cat file1
gert@ubuntu:~/test$ !c:s/1/2/
cat file2
hello
gert@ubuntu:~/test$
```

Chapter 15. File globbing

The shell is also responsible for **file globbing** (or dynamic filename generation). This chapter will explain **file globbing**.

* asterisk

The asterisk * is interpreted by the shell as a sign to generate filenames, matching the asterisk to any combination of characters (even none). When no path is given, the shell will use filenames in the current directory. See the man page of **glob(7)** for more information.

```
gert@ubuntu:~/glob$ ls
file1  file3  file55  FileA   Fileab  fileabc
file2  File4  File55  fileab  FileAB
gert@ubuntu:~/glob$ ls File*
File4  File55  FileA  Fileab  FileAB
gert@ubuntu:~/glob$ ls file*
file1  file2  file3  file55  fileab  fileabc
gert@ubuntu:~/glob$ ls *ile55
file55  File55
gert@ubuntu:~/glob$ ls F*ile55
File55
gert@ubuntu:~/glob$ ls F*55
File55
gert@ubuntu:~/glob$
```

By default hidden files are not included in the asterisk (***).** This is due to the fact that the shell option **dotglob** is not set.

```
gert@ubuntu:~/glob$ shopt dotglob
dotglob         off
gert@ubuntu:~/glob$ ls -a
.file1 file1  file3  file55  FileA   Fileab  fileabc
.file2 file2  File4  File55  fileab  FileAB  .fileabc
gert@ubuntu:~/glob$ ls *
file1  file3  file55  FileA   Fileab  fileabc
file2  File4  File55  fileab  FileAB
gert@ubuntu:~/glob$ ls -d .*
. .. .file1  .file2  .fileabc
```

If we turn the shell option **dotglob** on, hidden files will be included.

```
gert@ubuntu:~/glob$ shopt -s dotglob
gert@ubuntu:~/glob$ shopt dotglob
dotglob         on
gert@ubuntu:~/glob$ ls *
.file1 file1  file3  file55  FileA   Fileab  fileabc
.file2 file2  File4  File55  fileab  FileAB  .fileabc
gert@ubuntu:~/glob$
```

? question mark

Similar to the asterisk, the question mark **?** is interpreted by the shell as a sign to generate filenames, matching the question mark with exactly one character.

```
gert@ubuntu:~/glob$ ls
file1  file2  file3  File4  Filo4  File55  FileA  fileab  Fileab  FileAB  fileabc
gert@ubuntu:~/glob$ ls File?
File4  FileA
gert@ubuntu:~/glob$ ls Fil?4
File4  Filo4
gert@ubuntu:~/glob$ ls Fil??
File4  FileA  Filo4
gert@ubuntu:~/glob$ ls File??
File55  Fileab  FileAB
gert@ubuntu:~/glob$
```

[] square brackets

The square bracket **[** is interpreted by the shell as a sign to generate filenames, matching any of the characters between **[** and the first subsequent **]**. The order in this list between the brackets is not important. Each pair of brackets is replaced by exactly one character.

```
gert@ubuntu:~/glob$ ls
file1  file3  File5   FileA   fileab  FileAB
file2  File4  File55  Filea9  Fileab  fileabc
gert@ubuntu:~/glob$ ls File[5A]
File5 FileA
gert@ubuntu:~/glob$ ls File[A5]
File5 FileA
gert@ubuntu:~/glob$ ls File[A5][5b]
File55
gert@ubuntu:~/glob$ ls File[a5][5b]
File55  Fileab
gert@ubuntu:~/glob$ ls File[a5][5b][abcdefghijklm]
ls: File[a5][5b][abcdefghijklm]: No such file or directory
gert@ubuntu:~/glob$ ls file[a5][5b][abcdefghijklm]
fileabc
gert@ubuntu:~/glob$
```

You can also exclude characters from a list between square brackets with the exclamation mark **!**. And you are allowed to make combinations of these **wild cards**.

```
gert@ubuntu:~/glob$ ls
file1  file2  file3  File4 file55 File55  FileA  fileab  Fileab  FileAB  fileaZ
fileabc
gert@ubuntu:~/glob$ ls file[a5][!Z]
fileab
gert@ubuntu:~/glob$ ls file[!5]*
file1  file2  file3  fileab  fileaZ  fileabc
gert@ubuntu:~/glob$ ls file[!5]?
fileab  fileaZ
gert@ubuntu:~/glob$
```

a-z and 0-9 ranges

The bash shell will also understand ranges of characters between brackets.

```
gert@ubuntu:~/glob$ ls
file1  file3  File55  fileab  FileAB   fileabc  fileke98c
file2  File4  FileA   Filea9  Fileab   fileab2
gert@ubuntu:~/glob$ ls file[a-z]*
fileab  fileab2  fileabc  fileke98c
gert@ubuntu:~/glob$ ls file[0-9]
file1  file2  file3
gert@ubuntu:~/glob$ ls File[a5][a-z0-9]
File55  Fileab  Filea9
gert@ubuntu:~/glob$ ls file[a-z][a-z][0-9]*
fileab2  fileke98c
gert@ubuntu:~/glob$
```

Shell option "globasciiranges" and square brackets

In recent versions of Ubuntu, the default value of **globasciiranges is set to 'on'**, which means that the use of the default LANG (en_US.UTF-8) will provide you with **case sensitivity** while globbing.

```
gert@ubuntu:~/glob$ echo $LANG
en_US.UTF-8
gert@ubuntu:~/glob$ shopt globasciiranges
globasciiranges on
gert@ubuntu:~/glob$ ls [a-z]ile?
file1  file2  file3
gert@ubuntu:~/glob$ shopt -u globasciiranges
gert@ubuntu:~/glob$ shopt globasciiranges
globasciiranges off
gert@ubuntu:~/glob$ ls [a-z]ile?
file1  file2  file3  File4
gert@ubuntu:~/glob$
```

If you want to be sure that both small and capital letters will be included, you can combine both in the range. for example: ls File[a-zA-Z]

$LANG and square brackets

But, don't forget the influence of the **LANG** variable. Even if the shell option **globasciiranges** is **off**, this does **not guarantee** that **range** will be **case-insensitive**. This is due to the fact that some languages include lower case letters in an upper case range (and vice versa), but others do not!

```
gert@ubuntu:~/glob$ shopt -u globasciiranges
gert@ubuntu:~/glob$ shopt globasciiranges
globasciiranges off
gert@ubuntu:~/glob$ echo $LANG
en_US.UTF-8
gert@ubuntu:~/glob$ ls [a-z]ile?
file1  file2  file3  File4
gert@ubuntu:~/glob$ LANG=C
gert@ubuntu:~/glob$ echo $LANG
C
gert@ubuntu:~/glob$ ls [a-z]ile?
file1  file2  file3
gert@ubuntu:~/glob$ ls [A-Z]ile?
File4
gert@ubuntu:~/glob$
```

If you want to be sure that both small and capital letters will be included, you can combine both in the range. for example: ls File[a-zA-Z]

preventing file globbing

The **echo *** will echo a * when in an empty directory. And it will echo the names of all files when the directory is not empty.

```
gert@ubuntu:~$ mkdir test42
gert@ubuntu:~$ cd test42
gert@ubuntu:~/test42$ echo *
*
gert@ubuntu:~/test42$ touch file42 file33
gert@ubuntu:~/test42$ ls
file33 file42
gert@ubuntu:~/test42$ echo *
file33 file42
gert@ubuntu:~/test42$ echo ***** This is a title ******
file33 file42 This is a title file33 file42
```

Globbing can be prevented using quotes or by escaping the special characters, as shown in this screenshot.

```
gert@ubuntu:~/test42$ echo *
file33 file42
gert@ubuntu:~/test42$ echo \*
*
gert@ubuntu:~/test42$ echo '*'
*
gert@ubuntu:~/test42$ echo "*"
*
```

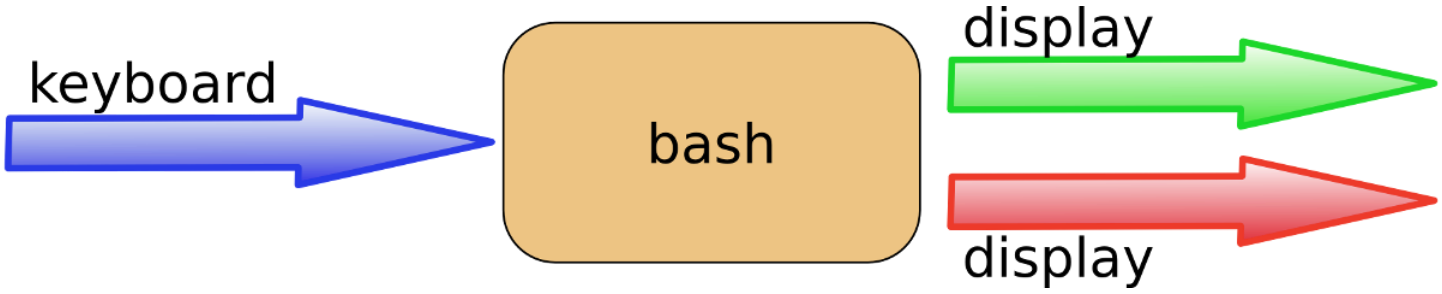
Chapter 16. I/O redirection

One of the powers of the Unix command line is the use of **input/output redirection** and **pipes**.
This chapter explains **redirection** of input, output and error streams.

stdin, stdout, and stderr

The bash shell has three basic streams; it takes input from **stdin** (stream **0**), it sends output to **stdout** (stream **1**) and it sends error messages to **stderr** (stream **2**) .
The drawing below has a graphical interpretation of these three streams.

The keyboard often serves as **stdin**, whereas **stdout** and **stderr** both go to the display. This can be confusing to new Linux users because there is no obvious way to recognize **stdout** from **stderr**. Experienced users know that separating output from errors can be very useful.

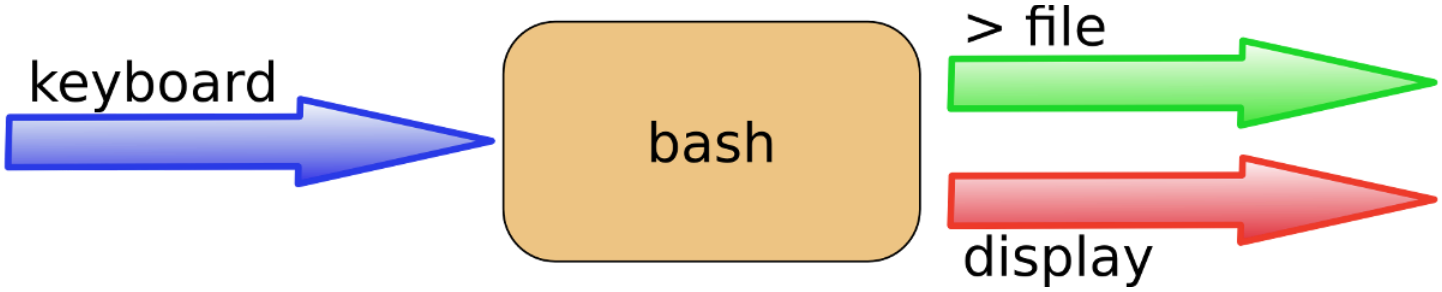


The next sections will explain how to redirect these streams.

output redirection

> stdout

stdout can be redirected with a **greater than** sign. While scanning the line, the shell will see the **>** sign and will clear the file.



The **>** notation is in fact the abbreviation of **1>** (**stdout** being referred to as stream **1**).

```
gert@ubuntu:~$ echo It is cold today!
It is cold today!
gert@ubuntu:~$ echo It is cold today! > winter.txt
gert@ubuntu:~$ cat winter.txt
It is cold today!
gert@ubuntu:~$ echo It is winter! > winter.txt
gert@ubuntu:~$ cat winter.txt
It is winter!
gert@ubuntu:~$
```

output file is erased

While scanning the line, the shell will see the > sign and **will clear the file**! Since this happens before resolving **argument 0**, this means that even when the command fails, the file will have been cleared!

```
gert@ubuntu:~$ cat winter.txt
It is winter!
gert@ubuntu:~$ zcho It is cold today! > winter.txt
-bash: zcho: command not found
gert@ubuntu:~$ cat winter.txt
gert@ubuntu:~$
```

noclobber

Erasing a file while using > can be prevented by setting the **noclobber** option.

```
gert@ubuntu:~$ cat winter.txt
It is cold today!
gert@ubuntu:~$ set -o noclobber
gert@ubuntu:~$ echo It is cold today! > winter.txt
-bash: winter.txt: cannot overwrite existing file
gert@ubuntu:~$ set +o noclobber
gert@ubuntu:~$
```

overruling noclobber

The **noclobber** can be overruled with **>|**

```
gert@ubuntu:~$ set -o noclobber
gert@ubuntu:~$ echo It is cold today! > winter.txt
-bash: winter.txt: cannot overwrite existing file
gert@ubuntu:~$ echo It is very cold today! >| winter.txt
gert@ubuntu:~$ cat winter.txt
It is very cold today!
gert@ubuntu:~$
```

>> append

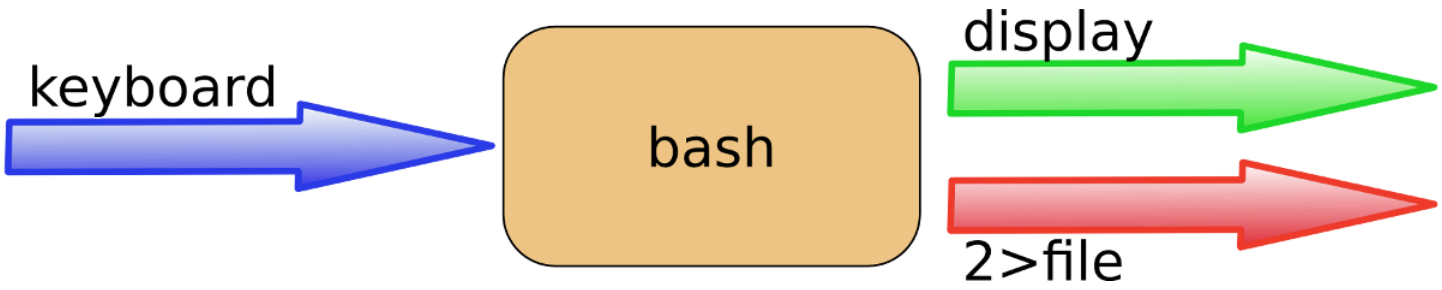
Use **>>** to **append** output to a file.

```
gert@ubuntu:~$ echo It is cold today! > winter.txt
gert@ubuntu:~$ cat winter.txt
It is cold today!
gert@ubuntu:~$ echo It is winter! >> winter.txt
gert@ubuntu:~$ cat winter.txt
It is cold today!
It is winter!
gert@ubuntu:~$
```

error redirection

2> stderr

Redirecting **stderr** is done with **2>**. This can be very useful to prevent error messages from cluttering your screen.



The command below shows redirection of **stdout** to a file, and **stderr** to **/dev/null**. Writing **1>** is the same as **>**.

```
gert@ubuntu:~$ find / > allfiles.txt  2> /dev/null
gert@ubuntu:~$
```

2>&1

To redirect both **stdout** and **stderr** to the same file, use **2>&1**.

```
gert@ubuntu:~$ find / > allfiles_and_errors.txt 2>&1
gert@ubuntu:~$
```

Note that the order of redirections is significant. For example, the command

```
ls > dirlist 2>&1
```

directs both standard output (file descriptor 1) and standard error (file descriptor 2) to the file dirlist, while the command

```
ls 2>&1 > dirlist
```

directs only the standard output to file dirlist, because the standard error was redirected to wherever standard output was redirected before the standard output was redirected to dirlist.

output redirection and pipes

By default you cannot grep inside **stderr** when using pipes on the command line, because only **stdout** is passed.

```
gert@ubuntu:~$ rm file42 file33 file1201 | grep file42
rm: cannot remove ‘file42’: No such file or directory
rm: cannot remove ‘file33’: No such file or directory
rm: cannot remove ‘file1201’: No such file or directory
```

With **2>&1** you can force **stderr** to go to **stdout**. This enables the next command in the pipe to act on both streams.

```
gert@ubuntu:~$ rm file42 file33 file1201 2>&1 | grep file42
rm: cannot remove ‘file42’: No such file or directory
```

You cannot use both **1>&2** and **2>&1** to switch **stdout** and **stderr**.

```
gert@ubuntu:~$ rm file42 file33 file1201 2>&1 1>&2 | grep file42
rm: cannot remove ‘file42’: No such file or directory
gert@ubuntu:~$ echo file42 2>&1 1>&2 | sed 's/file42/FILE42/'
FILE42
```

You need a third stream to switch stdout and stderr if you want to use filters on the error-stream.

```
gert@ubuntu:~$ rm file42 | sed 's/file42/FILE42/'    #no filtering on stream 2
rm: cannot remove ‘file42’: No such file or directory
```

```
gert@ubuntu:~$ rm file42 3>&1 1>&2 2>&3 | sed 's/file42/FILE42/'    #filtering
because stream 2 is now stream 1
rm: cannot remove ‘FILE42’: No such file or directory
```

joining stdout and stderr

The **&>** construction will redirect both **stdout** and **stderr** in one stream (to a file).

```
gert@ubuntu:~$ rm file42 &> out_and_err
gert@ubuntu:~$ cat out_and_err
rm: cannot remove ‘file42’: No such file or directory
gert@ubuntu:~$ echo file42 &> out_and_err
gert@ubuntu:~$ cat out_and_err
file42
gert@ubuntu:~$
```

The **|&** construction will put both **stdout** and **stderr** in one stream to give to the next filter (via the pipe).

```
gert@ubuntu:~$ ls /var/spool/[rc]* |& grep oo
/var/spool/cron:
ls: cannot open directory '/var/spool/cups': Permission denied
ls: cannot open directory '/var/spool/rsyslog': Permission denied
gert@ubuntu:~$
```

input redirection

< stdin

Redirecting **stdin** is done with < (short for 0<).

```
gert@ubuntu:~$ cat < text.txt
one
two
gert@ubuntu:~$ tr 'onetw' 'ONEZZ' < text.txt
ONE
ZZO
gert@ubuntu:~$
```

<< here document

The **here document** (sometimes called here-is-document) is a way to append input until a certain sequence (usually EOF) is encountered. The **EOF** marker can be typed literally or can be called with Ctrl-D.

```
gert@ubuntu:~$ cat <<EOF > text.txt
> one
> two
> EOF
gert@ubuntu:~$ cat text.txt
one
two
gert@ubuntu:~$ cat <<einde > text.txt
> brel
> einde
gert@ubuntu:~$ cat text.txt
brel
gert@ubuntu:~$
```

<<< here string

The **here string** can be used to directly pass strings to a command. The result is the same as using **echo string | command** (but you have one less process running).

```
gert@ubuntu:~$ base64 <<< linux-training.be
bGludXgtdHJhaW5pbmcuYmUK
gert@ubuntu:~$ base64 -d <<< bGludXgtdHJhaW5pbmcuYmUK
linux-training.be
```

confusing redirection

The shell will scan the whole line before applying redirection. The following command line is very readable and is correct.

```
cat winter.txt > snow.txt 2> errors.txt
```

But this one is also correct, but less readable.

```
2> errors.txt cat winter.txt > snow.txt
```

Even this will be understood perfectly by the shell.

```
< winter.txt > snow.txt 2> errors.txt cat
```

quick file clear

So what is the quickest way to clear a file ?

```
>winter.txt
```

And what is the quickest way to clear a file when the **noclobber** option is set ?

```
>|winter.txt
```

Chapter 17. Filters

Commands that are created to be used with a **pipe** are often called **filters**. These **filters** are very small programs that do one specific thing very efficiently. They can be used as **building blocks**.
This chapter will introduce you to the most common **filters**. The combination of simple commands and filters in a long **pipe** allows you to design elegant solutions.

cat

When between two **pipes**, the **cat** command does nothing (except putting **stdin** on **stdout**).

```
gert@ubuntu:~/pipes$ cat count.txt
one
two
three
four
five
gert@ubuntu:~/pipes$ tac count.txt | cat | cat | cat | cat | cat
five
four
three
two
one
gert@ubuntu:~/pipes$
```

tee

Writing long **pipes** in Unix is fun, but sometimes you may want intermediate results. This is where **tee** comes in handy. The **tee** filter puts **stdin** on **stdout** and also into a file. So **tee** is almost the same as **cat**, except that it has two identical outputs.

```
gert@ubuntu:~/pipes$ tac count.txt | tee temp.txt | tac
one
two
three
four
five
gert@ubuntu:~/pipes$ cat temp.txt
five
four
three
two
one
gert@ubuntu:~/pipes$
```

grep

The **grep** filter is famous among Unix users. The most common use of **grep** is to filter lines of text containing (or not containing) a certain string.

```
gert@ubuntu:~/pipes$ cat tennis.txt
Amelie Mauresmo, Fra
Kim Clijsters, BEL
Justine Henin, Bel
Serena Williams, usa
Venus Williams, USA
gert@ubuntu:~/pipes$ cat tennis.txt | grep Williams
Serena Williams, usa
Venus Williams, USA
```

You can write this without the cat.

```
gert@ubuntu:~/pipes$ grep Williams tennis.txt
Serena Williams, usa
Venus Williams, USA
```

One of the most useful options of grep is **grep -i** which filters in a case insensitive way.

```
gert@ubuntu:~/pipes$ grep Bel tennis.txt
Justine Henin, Bel
gert@ubuntu:~/pipes$ grep -i bel tennis.txt
Kim Clijsters, BEL
Justine Henin, Bel
gert@ubuntu:~/pipes$
```

Another very useful option is **grep -v** which outputs lines not matching the string.

```
gert@ubuntu:~/pipes$ grep -v Fra tennis.txt
Kim Clijsters, BEL
Justine Henin, Bel
Serena Williams, usa
Venus Williams, USA
gert@ubuntu:~/pipes$
```

And of course, both options can be combined to filter all lines not containing a case insensitive string.

```
gert@ubuntu:~/pipes$ grep -vi usa tennis.txt
Amelie Mauresmo, Fra
Kim Clijsters, BEL
Justine Henin, Bel
gert@ubuntu:~/pipes$
```

With **grep -A1** one line **after** the result is also displayed.

```
gert@ubuntu:~/pipes$ grep -A1 Henin tennis.txt
Justine Henin, Bel
Serena Williams, usa
```

With **grep -B1** one line **before** the result is also displayed.

```
gert@ubuntu:~/pipes$ grep -B2 Henin tennis.txt
Amelie Mauresmo, Fra
Kim Clijsters, BEL
Justine Henin, Bel
```

With **grep -C1** (context) one line **before** and one **after** are also displayed. All three options (A,B, and C) can display any number of lines (using e.g. A2, B4 or C20).

```
gert@ubuntu:~/pipes$ grep -C1 Henin tennis.txt
Kim Clijsters, BEL
Justine Henin, Bel
Serena Williams, usa
```

With **grep** you can also search for multiple different strings. In the command below we will search for lines containing Henin or Clijsters.

```
gert@ubuntu:~/pipes$ grep -e "Henin" -e "Clijsters" tennis.txt
Kim Clijsters, BEL
Justine Henin, Bel
```

cut

The **cut** filter can select columns from files, depending on a delimiter or a count of bytes. The screenshot below uses **cut** to filter for the username and userid in the **/etc/passwd** file. It uses the colon as a delimiter, and selects fields 1 and 3.

```
[gert@ubuntu:~/pipes$ cut -d: -f1,3 /etc/passwd | tail -4
figo:1000
pfaff:1001
harry:1002
hermione:1003
gert@ubuntu:~/pipes$
```

When using a space as the delimiter for **cut**, you have to quote the space.

```
gert@ubuntu:~/pipes$ cut -d" " -f1 tennis.txt
Amelie
Kim
Justine
Serena
Venus
gert@ubuntu:~/pipes$
```

This example uses **cut** to display the second to the seventh character of **/etc/passwd**.

```
gert@ubuntu:~/pipes$ cut -c2-7 /etc/passwd | tail -4
igo:x:
faff:x
arry:x
ermion
gert@ubuntu:~/pipes$
```

tr

You can translate characters with **tr**. The screenshot shows the translation of all occurrences of e to E.

```
gert@ubuntu:~/pipes$ cat tennis.txt | tr 'e' 'E'
AmEliE MaurEsmo, Fra
Kim ClijstErs, BEL
JustinE HEnin, BEl
SErEna Williams, usa
VEnus Williams, USA
```

Here we set all letters to uppercase by defining two ranges.

```
gert@ubuntu:~/pipes$ cat tennis.txt | tr 'a-z' 'A-Z'
AMELIE MAURESMO, FRA
KIM CLIJSTERS, BEL
JUSTINE HENIN, BEL
SERENA WILLIAMS, USA
VENUS WILLIAMS, USA
gert@ubuntu:~/pipes$
```

Here we translate all newlines to spaces.

```
gert@ubuntu:~/pipes$ cat count.txt
one
two
three
four
five
gert@ubuntu:~/pipes$ cat count.txt | tr '\n' ' '
one two three four five gert@ubuntu:~/pipes$
```

The **tr -s** filter can also be used to squeeze multiple occurrences of a character to one.

```
gert@ubuntu:~/pipes$ cat spaces.txt
one    two        three
     four               five     six
gert@ubuntu:~/pipes$ cat spaces.txt | tr -s ' '
one two three
 four five six
gert@ubuntu:~/pipes$
```

You can also use **tr** to 'encrypt' texts with **rot13**.

```
gert@ubuntu:~/pipes$ cat count.txt
one
two
three
four
five
gert@ubuntu:~/pipes$ cat count.txt | tr 'a-z' 'nopqrstuvwxyzabcdefghijklm'
bar
gjb
guerr
sbhe
svir
gert@ubuntu:~/pipes$ cat count.txt | tr 'a-z' 'nopqrstuvwxyzabcdefghijklm' >
encrypted.txt
gert@ubuntu:~/pipes$ cat encrypted.txt
bar
gjb
guerr
sbhe
svir
gert@ubuntu:~/pipes$ cat encrypted.txt | tr 'a-z' 'n-za-m'
one
two
three
four
five
gert@ubuntu:~/pipes$
```

This last example uses **tr -d** to delete characters.

```
gert@ubuntu:~/pipes$ cat tennis.txt | tr -d e
Amli Maursmo, Fra
Kim Clijstrs, BEL
Justin Hnin, Bl
Srna Williams, usa
Vnus Williams, USA
```

wc

Counting words, lines and characters is easy with **wc**.

```
gert@ubuntu:~/pipes$ wc tennis.txt
  5  15 100 tennis.txt
gert@ubuntu:~/pipes$ wc -l tennis.txt
5 tennis.txt
gert@ubuntu:~/pipes$ wc -w tennis.txt
15 tennis.txt
gert@ubuntu:~/pipes$ wc -c tennis.txt
100 tennis.txt
gert@ubuntu:~/pipes$
```

sort

The **sort** filter will default to an alphabetical sort.

```
gert@ubuntu:~/pipes$ cat music.txt
Queen
Brel
Led Zeppelin
Abba
gert@ubuntu:~/pipes$ sort music.txt
Abba
Brel
Led Zeppelin
Queen
```

But the **sort** filter has many options to tweak its usage. This example shows sorting different columns (column 1 or column 2).

```
gert@ubuntu:~/pipes$ sort -k1 country.txt
Belgium, Brussels, 10
France, Paris, 60
Germany, Berlin, 100
Iran, Teheran, 70
Italy, Rome, 50
gert@ubuntu:~/pipes$ sort -k2 country.txt
Germany, Berlin, 100
Belgium, Brussels, 10
France, Paris, 60
Italy, Rome, 50
Iran, Teheran, 70
```

The commands below show the difference between an alphabetical sort and a numerical sort (both on the third column).

```
gert@ubuntu:~/pipes$ sort -k3 country.txt
Belgium, Brussels, 10
Germany, Berlin, 100
Italy, Rome, 50
France, Paris, 60
Iran, Teheran, 70
gert@ubuntu:~/pipes$ sort -n -k3 country.txt
Belgium, Brussels, 10
Italy, Rome, 50
France, Paris, 60
Iran, Teheran, 70
Germany, Berlin, 100
```

uniq

With **uniq** you can remove duplicates from a **sorted list**.

```
gert@ubuntu:~/pipes$ cat music.txt
Queen
Brel
Queen
Abba
gert@ubuntu:~/pipes$ sort music.txt
Abba
Brel
Queen
Queen
gert@ubuntu:~/pipes$ sort music.txt |uniq
Abba
Brel
Queen
```

uniq can also count occurrences with the **-c** option.

```
gert@ubuntu:~/pipes$ sort music.txt |uniq -c
      1 Abba
      1 Brel
      2 Queen
```

comm

Comparing streams (or files) can be done with the command **comm**. By default **comm** will output three columns. In this example, Abba, Cure and Queen are in both lists, Bowie and Sweet are only in the first file, Turner is only in the second. **Attention!! Both files need to be sorted!**

```
gert@ubuntu:~/pipes$ cat > list1.txt
Abba
Bowie
Cure
Queen
Sweet
gert@ubuntu:~/pipes$ cat > list2.txt
Abba
Cure
Queen
Turner
gert@ubuntu:~/pipes$ comm list1.txt list2.txt
                Abba
Bowie
                Cure
                Queen
Sweet
        Turner
```

The output of **comm** can be easier to read when outputting only a single column. The digits point out which output columns should not be displayed.

```
gert@ubuntu:~/pipes$ comm -12 list1.txt list2.txt
Abba
Cure
Queen
gert@ubuntu:~/pipes$ comm -13 list1.txt list2.txt
Turner
gert@ubuntu:~/pipes$ comm -23 list1.txt list2.txt
Bowie
Sweet
```

od

European humans like to work with ascii characters, but computers store files in bytes. The example below creates a simple file, and then uses **od** to show the contents of the file in hexadecimal bytes

```
gert@ubuntu:~/test$ cat > text.txt
abcdefg
1234567
gert@ubuntu:~/test$ od -t x1 text.txt
0000000 61 62 63 64 65 66 67 0a 31 32 33 34 35 36 37 0a
0000020
```

The same file can also be displayed in octal bytes.

```
gert@ubuntu:~/test$ od -b text.txt
0000000 141 142 143 144 145 146 147 012 061 062 063 064 065 066 067 012
0000020
```

And here is the file in ascii (or backslashed) characters.

```
gert@ubuntu:~/test$ od -c text.txt
0000000   a   b   c   d   e   f   g  \n   1   2   3   4   5   6   7  \n
0000020
```

sed

The **s**tream **ed**itor **sed** can perform editing functions in the stream, using **regular expressions**.

```
gert@ubuntu:~/pipes$ echo level5 | sed 's/5/42/'
level42
gert@ubuntu:~/pipes$ echo level5 | sed 's/level/jump/'
jump5
```

Add **g** for global replacements (all occurrences of the string per line).

```
gert@ubuntu:~/pipes$ echo level5 level7 | sed 's/level/jump/'
jump5 level7
gert@ubuntu:~/pipes$ echo level5 level7 | sed 's/level/jump/g'
jump5 jump7
```

With **d** you can remove lines from a stream containing a character.

```
gert@ubuntu:~/test42$ cat tennis.txt
Venus Williams, USA
Martina Hingis, SUI
Justine Henin, BE
Serena williams, USA
Kim Clijsters, BE
Yanina Wickmayer, BE
gert@ubuntu:~/test42$ cat tennis.txt | sed '/BE/d'
Venus Williams, USA
Martina Hingis, SUI
Serena williams, USA
```

pipe examples

who | wc

How many users are logged on to this system ?

```
gert@ubuntu:~/pipes$ who
root     tty1         Jul 25 10:50
gert     pts/0        Jul 25 09:29 (laika)
harry    pts/1        Jul 25 12:26 (barry)
gert     pts/2        Jul 25 12:26 (pasha)
gert@ubuntu:~/pipes$ who | wc -l
4
```

who | cut | sort

Display a sorted list of logged on users.

```
gert@ubuntu:~/pipes$ who | cut -d' ' -f1 | sort
gert
gert
harry
root
```

Display a sorted list of logged on users, but every user only once .

```
gert@ubuntu:~/pipes$ who | cut -d' ' -f1 | sort | uniq
gert
harry
root
```

grep | cut

Display a list of all bash **user accounts** on this computer. Users accounts are explained in detail later.

```
gert@ubuntu:~$ grep bash /etc/passwd
root:x:0:0:root:/root:/bin/bash
gert:x:1000:1000:gert,,,:/home/gert:/bin/bash
serena:x:1001:1001::/home/serena:/bin/bash
gert@ubuntu:~$ grep bash /etc/passwd | cut -d: -f1
root
gert
serena
```

Chapter 18. Basic Unix tools

This chapter introduces commands to **find** or **locate** files and to **compress** files, together with other common tools that were not discussed before. While the tools discussed here are technically not considered **filters**, they can be used in **pipes**.

find

The **find** command can be very useful at the start of a pipe to search for files. Here are some examples. You might want to add **2>/dev/null** to the command lines to avoid cluttering your screen with error messages.
Find all files in **/etc** (and all subdirs) and put the list in etcfiles.txt

```
find /etc > etcfiles.txt
```

Find all files of the entire system and put the list in allfiles.txt

```
find / > allfiles.txt
```

Find files that end in .conf in the current directory (and all subdirs).

```
find . -name "*.conf"
```

Find files of type file (not directory, pipe or etc.) that end in .conf.

```
find . -type f -name "*.conf"
```

Find files of type directory that end in .bak .

```
find /data -type d -name "*.bak"
```

Find files that are newer than file42.txt

```
find . -newer file42.txt
```

Find can also execute another command on every file found. This example will look for *.odf files and copy them to /backup/.

```
find /data -name "*.odf" -exec cp {} /backup/ \;
```

Find can also execute, after your confirmation, another command on every file found. This example will remove *.odf files if you approve of it for every file found.

```
find /data -name "*.odf" -ok rm {} \;
```

locate

The **locate** tool is very different from **find** in that it uses an index to locate files. This is a lot faster than traversing all the directories, but it also means that it is always outdated. If the index does not exist yet, then you have to create it (as root on Red Hat Enterprise Linux) with the **updatedb** command.

```
gert@ubuntu:~$ ls all*
allfiles.txt
gert@ubuntu:~$ ls backups/all*
allfiles.txt.backup
gert@ubuntu:~$ sudo updatedb         #om de database up-to-date te brengen
gert@ubuntu:~$ locate allfiles
/home/gert/allfiles.txt
/home/gert/backups/allfiles.txt.backup
gert@ubuntu:~$
```

Most Linux distributions will schedule the **updatedb** to run once every day.

date

The **date** command can display the date, time, time zone and more.

```
gert@ubuntu:~$ date
Sat Apr 17 12:44:30 CEST 2010
```

A date string can be customised to display the format of your choice. Check the man page for more options.

```
gert@ubuntu:~$ date +'%A %d-%m-%Y'
Saturday 17-04-2010
```

Time on any Unix is calculated in number of seconds since 1969 (the first second being the first second of the first of January 1970). Use **date +%s** to display Unix time in seconds.

```
gert@ubuntu:~$ date +%s
1271501080
```

When will this seconds counter reach two thousand million ?

```
gert@ubuntu:~$ date -d '1970-01-01 + 2000000000 seconds'
Wed May 18 04:33:20 CEST 2033
```

cal

The **cal** command displays the current month, with the current day highlighted.

```
gert@ubuntu:~$ cal
     April 2019
Su Mo Tu We Th Fr Sa
              1  2  3
 4  5  6  7  8  9 10
11 12 13 14 15 16 17
18 19 20 21 22 23 24
25 26 27 28 29 30
```

You can select any month in the past or the future.

```
gert@ubuntu:~$ cal 2 1970
   February 1970
Su Mo Tu We Th Fr Sa
 1  2  3  4  5  6  7
 8  9 10 11 12 13 14
15 16 17 18 19 20 21
22 23 24 25 26 27 28
```

sleep

The **sleep** command is sometimes used in scripts to wait a number of seconds. This example shows a five second **sleep**.

```
gert@ubuntu:~$ sleep 5
gert@ubuntu:~$
```

time

The **time** command can display how long it takes to execute a command. The **date** command takes only a little time.

```
gert@ubuntu:~$ time date
Sat Apr 17 13:08:27 CEST 2010

real    0m0.014s
user    0m0.008s
sys     0m0.006s
```

The **sleep 5** command takes five **real** seconds to execute, but consumes little **cpu time**.

```
gert@ubuntu:~$ time sleep 5

real    0m5.009s
user    0m0.002s
sys     0m0.000s
```

The listing of all files and redirection of these results into the file takes about 4 seconds.

```
gert@ubuntu:~$ time find / > myfiles 2>/dev/null

real    0m4.368s
user    0m0.247s
sys     0m1.539s
```

gzip - gunzip

Users never have enough disk space, so compression comes in handy. The **gzip** command can make files take up less space.

```
gert@ubuntu:~$ ls -lh text.txt
-rw-rw-r-- 1 gert gert 6.4M Apr 17 13:11 text.txt
gert@ubuntu:~$ gzip text.txt
gert@ubuntu:~$ ls -lh text.txt.gz
-rw-rw-r-- 1 gert gert 760K Apr 17 13:11 text.txt.gz
```

You can get the original back with **gunzip**.

```
gert@ubuntu:~$ gunzip text.txt.gz
gert@ubuntu:~$ ls -lh text.txt
-rw-rw-r-- 1 gert gert 6.4M Apr 17 13:11 text.txt
```

zcat - zmore

Text files that are compressed with **gzip** can be viewed with **zcat** and **zmore**.

```
gert@ubuntu:~$ head -4 text.txt
/
/opt
/opt/VBoxGuestAdditions-3.1.6
/opt/VBoxGuestAdditions-3.1.6/routines.sh
gert@ubuntu:~$ gzip text.txt
gert@ubuntu:~$ zcat text.txt.gz | head -4
/
/opt
/opt/VBoxGuestAdditions-3.1.6
/opt/VBoxGuestAdditions-3.1.6/routines.sh
```

bzip2 - bunzip2

Files can also be compressed with **bzip2** which takes a little more time than **gzip**, but compresses better.

```
gert@ubuntu:~$ bzip2 text.txt
gert@ubuntu:~$ ls -lh text.txt.bz2
-rw-rw-r-- 1 gert gert 569K Apr 17 13:11 text.txt.bz2
```

Files can be uncompressed again with **bunzip2**.

```
gert@ubuntu:~$ bunzip2 text.txt.bz2
gert@ubuntu:~$ ls -lh text.txt
-rw-rw-r-- 1 gert gert 6.4M Apr 17 13:11 text.txt
```

bzcat - bzmore

And in the same way **bzcat** and **bzmore** can display files compressed with **bzip2**.

```
gert@ubuntu:~$ bzip2 text.txt
gert@ubuntu:~$ bzcat text.txt.bz2 | head -4
/
/opt
/opt/VBoxGuestAdditions-3.1.6
/opt/VBoxGuestAdditions-3.1.6/routines.sh
```

tar (tape archiver)

This tool archives/extracts a directory structure **including ownership and permission settings** into a single file.

Creating a **tar** archive from your home directory

```
gert@ubuntu:~$ sudo tar -cf /tmp/myhome.tar /home/gert
tar: Removing leading `/' from member names
gert@ubuntu:~$ ls -lh /tmp/my*
-rw-rw-r-- 1 root root 287M okt 19 10:40 /tmp/myhome.tar
gert@ubuntu:~$
```

Extracting the **tar** archive

```
gert@ubuntu:~$ mkdir myhomebackupfiles && cd myhomebackupfiles
gert@ubuntu:~/myhomebackupfiles$ tar -xf /tmp/myhome.tar
gert@ubuntu:~/myhomebackupfiles$ tree
.
└── home
    └── gert
        ├── count.txt
        ├── Desktop
        ├── Documents
        │   └── school
        │       ├── aardrijkskunde_oef01
        │       └── semester1
        │           └── kwartaal1
        │               └── DesktopOS
        │                   └── Linux
        │
```

A tar file is often compressed with an **option** for the tar command. This can be done with gzip which results in a file with extension "tar.gz". This compressed tar file is called a **tarball**.

```
gert@ubuntu:~$ sudo tar -czf /tmp/myhome.tar.gz /home/gert
tar: Removing leading `/' from member names
gert@ubuntu:~$ ls -lh /tmp/my*
-rw-rw-r-- 1 root root 287M okt 19 10:40 /tmp/myhome.tar
-rw-rw-r-- 1 root root 243M okt 19 10:40 /tmp/myhome.tar.gz
gert@ubuntu:~$ tar -xzf /tmp/myhome.tar.gz -C /tmp/
gert@ubuntu:~$ tree /tmp/home
/tmp/home
└── gert
    ├── count.txt
    ├── Desktop
    ├── Documents
    │   └── school
    │       ├── aardrijkskunde_oef01
    │       └── semester1
    │           └── kwartaal1
    │               └── DesktopOS
    │                   └── Linux
    │
```

When creating a tar file, there is a **difference** between using a **relative** path and a **absolute** path (for specifying the source directory). The leading slash of the path is always removed, but with a absolute path the whole path is put in the tar file. Let's do the same with a relative path.

```
gert@ubuntu:~$ cd /home
gert@ubuntu:/home$ ls
gert
gert@ubuntu:/home$ sudo tar -czf /tmp/myhome_relative.tar.gz gert
tar: Removing leading `/' from member names
gert@ubuntu:~$ ls -lh /tmp/my*
-rw-rw-r-- 1 root root 243M okt 19 10:40 /tmp/myhome_relative.tar.gz
-rw-rw-r-- 1 root root 287M okt 19 10:40 /tmp/myhome.tar
-rw-rw-r-- 1 root root 243M okt 19 10:40 /tmp/myhome.tar.gz
gert@ubuntu:~$ mkdir myhomerestore && cd myhomerestore
gert@ubuntu:~/myhomerestore$ tar -xzf /tmp/myhome_relative.tar.gz
gert@ubuntu:~/myhomerestore$ tree
.
└── gert
    ├── count.txt
    ├── Desktop
    ├── Documents
    │   └── school
    │       ├── aardrijkskunde_oef01
    │       └── semester1
    │           └── kwartaal1
    │               └── DesktopOS
    │                   └── Linux
    │
```

Notice that there is no directory "home" in front of the directory "gert". For a backup with which you want to restore to the same directories, it might be best to use a absolute path. Otherwise, it can be easier to use a relative path.

Chapter 19. Regular expressions

Regular expressions are a very powerful tool in Linux. They can be used with a variety of programs like bash, vi, rename, grep, sed, and more.
This chapter introduces you to the basics of **regular expressions**.

regex versions

There are three different versions of regular expression syntax:

```
BRE: Basic Regular Expressions
ERE: Extended Regular Expressions
PRCE: Perl Regular Expressions
```

Depending on the tool being used, one or more of these syntaxes can be used.
For example the **grep** tool has the **-E** option to force a string to be read as ERE while **-G** forces BRE (which **is the default**) and **-P** forces PRCE.
Note that **grep** also has **-F** to force the string to be read literally.
The **sed** tool also has options to choose a regex syntax.
Read the manual of the tools you use!

grep

print lines matching a pattern

grep is a popular Linux tool to search for lines that match a certain pattern. Below are some examples of the simplest **regular expressions**.
This is the contents of the test file. This file contains three lines (or three **newline** characters).

```
gert@ubuntu:~$ cat names
Tania
Daisy
Laura
Valentina
```

When **grepping** for a single character, only the lines containing that character are returned.

```
gert@ubuntu:~$ grep u names
Laura
gert@ubuntu:~$ grep e names
Valentina
gert@ubuntu:~$ grep i names
Tania
Daisy
Valentina
```

The pattern matching in this example should be very straightforward; if the given character occurs on a line, then **grep** will return that line.

concatenating characters

Two concatenated characters will have to be concatenated in the same way to have a match.
This example demonstrates that **ia** will match Tan**ia** but not V**a**lent**i**na and **in** will match Valent**in**a but not Ta**ni**a.

```
gert@ubuntu:~$ grep a names
Tania
Daisy
Laura
Valentina
gert@ubuntu:~$ grep ia names
Tania
gert@ubuntu:~$ grep in names
Valentina
gert@ubuntu:~$
```

one or the other

PRCE and ERE both use the pipe symbol to signify OR. In this example we **grep** for lines containing the letter i or the letter a.

```
gert@ubuntu:~$ cat list
Tania
Tini
Laura
Tom
gert@ubuntu:~$ grep -E 'i|a' list
Tania
Tini
Laura
```

Note that you can also use the **-e** option multiple times to search for all patterns.

```
gert@ubuntu:~$ grep -e 'i' -e 'a' list
Tania
Laura
```

BRE vs ERE

In basic regular expressions (BRE) the meta-characters ?, +, {, |, (and) lose their special meaning. You need to use the backslashed version to interpret right, like \?, \+, \{, \|, \(and \).

```
gert@ubuntu:~$ cat list
Tania
Laura
```

```
gert@ubuntu:~$ grep 'i|a' list
```

```
gert@ubuntu:~$ grep 'i\|a' list
Tania
Laura
```

zero, one or more

The ***** signifies **zero, one or more** occurences of the **previous character**.

```
gert@ubuntu:~$ cat list2
ll
lol
lool
loool
gert@ubuntu:~$ grep 'o*' list2
ll
lol
lool
loool
```

one or more

The **+** signifies **one or more** of the **previous character**.

```
gert@ubuntu:~$ cat list2
ll
lol
lool
loool
gert@ubuntu:~$ grep -E 'o+' list2
lol
lool
loool
gert@ubuntu:~$
```

a dot for any character

In a **regex** a simple **dot** can signify **any character**.

```
gert@ubdesk:~$ cat chickens
tik
tak
tok
jip
jap
```

```
gert@ubdesk:~$ grep 't.k' chickens
tik
tak
tok
```

```
gert@ubuntu:~$ echo 2014-04-01 | sed 's/....-..-../YYYY-MM-DD/'
YYYY-MM-DD
gert@ubuntu:~$ echo abcd-ef-gh | sed 's/....-..-../YYYY-MM-DD/'
YYYY-MM-DD
```

match the end of a string

For the following examples, we will use this file.

```
gert@ubuntu:~$ cat names
Tania
Daisy
Laura
Valentina
Fleur
Floor
```

The two examples below show how to use the **dollar character** to match the end of a string.

```
gert@ubuntu:~$ grep a$ names
Tania
Laura
Valentina
gert@ubuntu:~$ grep r$ names
Fleur
Floor
```

match the start of a string

The **caret character (^)** will match a string at the start (or the beginning) of a line.
Given the same file as above, here are two examples.

```
gert@ubuntu:~$ cat names
Tania
Daisy
Laura
Valentina
Fleur
Floor
```

```
gert@ubuntu:~$ grep ^Val names
Valentina
gert@ubuntu:~$ grep ^F names
Fleur
Floor
```

Both the dollar sign and the little hat are called **anchors** in a regex.

separating words

Regular expressions use a **\b** sequence to reference a word separator. Take for example this file:

```
gert@ubuntu:~$ cat text
The governer is governing.
The winter is over.
Can you get over there?
```

Simply grepping for **over** will give too many results.

```
gert@ubuntu:~$ grep over text
The governer is governing.
The winter is over.
Can you get over there?
```

Surrounding the searched word with spaces is not a good solution (because other characters can be word separators). This screenshot below show how to use **\b** to find only the searched word:

```
gert@ubuntu:~$ grep '\bover\b' text
The winter is over.
Can you get over there?
gert@ubuntu:~$
```

Note that **grep** also has a **-w** option to grep for words.

```
gert@ubuntu:~$ cat text
The governer is governing.
The winter is over.
Can you get over there?
gert@ubuntu:~$ grep -w over text
The winter is over.
Can you get over there?
gert@ubuntu:~$
```

grep features

Sometimes it is easier to combine a simple regex with **grep** options, than it is to write a more complex regex. These options were discussed before:

```
grep -i
grep -v
grep -A5
grep -B5
grep -C5
```

preventing shell expansion of a regex

The dollar sign is a special character, both for the regex and also for the shell (remember variables and embedded shells). Therefore it is advised to always quote the regex, this prevents shell expansion.

```
gert@ubuntu:~$ cat names
Tania
Daisy
Laura
Valentina
Fleur
Floor

gert@ubuntu:~$ grep 'r$' names
Fleur
Floor

gert@ubuntu:~$ cat students
1A - Glenn Peeters
1A - Bea Kumpen
1A - Bea Custers
1B - John Menten

gert@ubuntu:~$ cat students | grep Bea Custers
grep: Custers: No such file or directory

gert@ubuntu:~$ cat students | grep "Bea Custers"
1A - Bea Custers

gert@ubuntu:~$ cat students | grep 'Bea Custers'
1A - Bea Custers
```

rename

the rename command

On Debian Linux the **/usr/bin/rename** command is a **perl** script.

```
gert@ubdesk:~$ which rename
/usr/bin/rename

gert@ubdesk:~$ ls -l /usr/bin/rename
lrwxrwxrwx 1 root root 24 sep 20 09:34 /usr/bin/rename -> /etc/alternatives/rename

gert@ubdesk:~$ ls -l /etc/alternatives/rename
lrwxrwxrwx 1 root root 20 sep 20 09:34 /etc/alternatives/rename ->
/usr/bin/file-rename

gert@ubdesk:~$ file /usr/bin/file-rename
/usr/bin/file-rename: a /usr/bin/perl -w script, ASCII text executable

gert@ubdesk:~$
```

Red Hat derived systems do not install the same **rename** command, so this section does not describe **rename** on Red Hat (unless you copy the perl script manually).
There is often confusion on the internet about the rename command because solutions that work fine in Debian (and Ubuntu, xubuntu, Mint, ...) cannot be used in Red Hat (and CentOS, Fedora, ...).

perl

The **rename** command is actually a perl script that uses **perl regular expressions**. The complete manual for these can be found by typing **perldoc perlrequick** (after installing **perldoc**).

```
root@ubuntu:~# apt install perl-doc
The following NEW packages will be installed:
  perl-doc
0 packages upgraded, 1 newly installed, 0 to remove and 0 not upgraded.
Need to get 8,170 kB of archives. After unpacking 13.2 MB will be used.
Get: 1 http://mirrordirector.raspbian.org/raspbian/ wheezy/main perl-do...
Fetched 8,170 kB in 19s (412 kB/s)
Selecting previously unselected package perl-doc.
(Reading database ... 67121 files and directories currently installed.)
Unpacking perl-doc (from .../perl-doc_5.14.2-21+rpi2_all.deb) ...
Adding 'diversion of /usr/bin/perldoc to /usr/bin/perldoc.stub by perl-doc'
Processing triggers for man-db ...
Setting up perl-doc (5.14.2-21+rpi2) ...

root@ubuntu:~# perldoc perlrequick
```

well known syntax

The most common use of the **rename** is to search for filenames matching a certain **string** and replacing this string with an **other string**.
This is often presented as **s/string/other string/** as seen in this example:

```
gert@ubuntu:~$ ls
abc       allfiles.TXT  bllfiles.TXT  Scratch   tennis2.TXT
abc.conf  backup        cllfiles.TXT  temp.TXT  tennis.TXT
gert@ubuntu:~$ rename 's/TXT/text/' *
gert@ubuntu:~$ ls
abc       allfiles.text  bllfiles.text  Scratch    tennis2.text
abc.conf  backup         cllfiles.text  temp.text  tennis.text
```

And here is another example that uses **rename** with the well know syntax to change the extensions of the same files once more:

```
gert@ubuntu:~$ ls
abc       allfiles.text  bllfiles.text  Scratch    tennis2.text
abc.conf  backup         cllfiles.text  temp.text  tennis.text
gert@ubuntu:~$ rename 's/text/txt/' *.text
gert@ubuntu:~$ ls
abc       allfiles.txt  bllfiles.txt  Scratch   tennis2.txt
abc.conf  backup        cllfiles.txt  temp.txt  tennis.txt
gert@ubuntu:~$
```

These two examples appear to work because the strings we used only exist at the end of the filename. Remember that file extensions have no meaning in the bash shell.
The next example shows what can go wrong with this syntax.

```
gert@ubuntu:~$ touch atxt.txt
gert@ubuntu:~$ rename 's/txt/problem/' atxt.txt
gert@ubuntu:~$ ls
abc       allfiles.txt  backup        cllfiles.txt  temp.txt     tennis.txt
abc.conf  aproblem.txt  bllfiles.txt  Scratch       tennis2.txt
gert@ubuntu:~$
```

Only the **first occurrence** of the searched string is **replaced**.

a global replace

The syntax used in the previous example can be described as **s/regex/replacement/**. This is simple and straightforward, you enter a **regex** between the first two slashes and a **replacement string** between the last two.
This example expands this syntax only a little, by adding a **modifier**.

```
gert@ubuntu:~$ rename -n 's/TXT/txt/g' aTXT.TXT
aTXT.TXT renamed as atxt.txt
gert@ubuntu:~$
```

The syntax we use now can be described as **s/regex/replacement/g** where s signifies **switch** and g stands for **global**.
Note that this example used the **-n** switch to show what is being done (instead of actually renaming the file).

case insensitive replace

Another **modifier** that can be useful is **i**. this example shows how to replace a case insensitive string with another string.

```
gert@ubuntu:~/files$ ls
file1.text  file2.TEXT  file3.txt
gert@ubuntu:~/files$ rename 's/\.text/.txt/i' *
gert@ubuntu:~/files$ ls
file1.txt  file2.txt  file3.txt
gert@ubuntu:~/files$
```

renaming extensions

Command line Linux has no knowledge of MS-DOS like extensions, but many end users and graphical applications do use them.
Here is an example on how to use **rename** to only rename the file extension. It uses the dollar sign to mark the ending of the filename.

```
gert@ubuntu:~$ ls *.txt
allfiles.txt  bllfiles.txt  cllfiles.txt  really.txt.txt  temp.txt  tennis.txt
gert@ubuntu:~$ rename 's/\.txt$/.TXT/' *
gert@ubuntu:~$ ls *.TXT
allfiles.TXT  bllfiles.TXT    cllfiles.TXT    really.txt.TXT
temp.TXT      tennis.TXT
gert@ubuntu:~$
```

Note that the **dollar sign** in the regex means **at the end**. Without the dollar sign this command would fail on the really.txt.txt file.

sed

stream editor

The **stream editor** or short **sed** uses **regex** for stream editing.

In this example **sed** is used to replace a string.

```
echo Sunday | sed 's/Sun/Mon/'
Monday
```

The slashes can be replaced by a couple of other characters, which can be handy in some cases to improve readability.

```
echo Sunday | sed 's:Sun:Mon:'
Monday
echo Sunday | sed 's_Sun_Mon_'
Monday
echo Sunday | sed 's|Sun|Mon|'
Monday
```

interactive editor

While **sed** is meant to be used in a stream, it can also be used **in-place** on a file.

```
gert@ubuntu:~/files$ echo Sunday > today
gert@ubuntu:~/files$ cat today
Sunday
gert@ubuntu:~/files$ sed -i 's/Sun/Mon/' today
gert@ubuntu:~/files$ cat today
Monday
```

simple back referencing

The **ampersand** character can be used to reference the searched (and found) string.
In this example the **ampersand** is used to double the occurrence of the found string.

```
gert@ubuntu:~$ echo It is my Sun | sed 's/Sun/great &day/'
It is my great Sunday
gert@ubuntu:~$ echo Sunday | sed 's/Sun/&&/'
SunSunday
gert@ubuntu:~$ echo Sunday | sed 's/day/&&/'
Sundayday
```

You could also use this to put a certain line in comments.

```
gert@ubserv:~$ cat /etc/network/interfaces
...
# The primary network interface
auto ens33
iface ens33 inet dhcp
```

```
gert@ubserv:~$ sed -i 's/auto ens../#&/' /etc/network/interfaces
```

```
gert@ubserv:~$ cat /etc/network/interfaces
...
# The primary network interface
#auto ens33
iface ens33 inet dhcp
```

back referencing

Parentheses (often called round brackets) are used to group sections of the regex so they can later be referenced.
Consider this simple example:

```
gert@ubuntu:~$ echo Sunday | sed 's_\(Sun\)_\1ny_'
Sunnyday
gert@ubuntu:~$ echo Sunday | sed 's_\(Sun\)_\1ny \1_'
Sunny Sunday
```

multiple back referencing

When more than one pair of **parentheses** is used, each of them can be referenced separately by consecutive numbers.

```
gert@ubuntu:~$ echo 2024-04-01 | sed 's/\(....\)-\(..\)-\(..\)/\1+\2+\3/'
2024+04+01
gert@ubuntu:~$ echo 2024-04-01 | sed 's/\(....\)-\(..\)-\(..\)/\3:\2:\1/'
01:04:2024
```

Or with the **-r** option for Extended Regular Expressions

```
gert@ubuntu:~$ echo 2024-04-01 | sed -r 's/(....)-(..)-(..)/\3:\2:\1/'
01:04:2024
```

This feature is called **grouping**.

white space

The **\s** can refer to white space such as a **space** or a **tab**.
This example looks for white spaces (\s) globally and replaces them with 1 space.

```
gert@ubuntu:~$ echo -e 'today\tis\twarm'
today   is      warm
gert@ubuntu:~$ echo -e 'today\tis\twarm' | sed 's_\s_ _g'
today is warm
```

optional occurrence

A **question mark** signifies that the **previous character** is **optional**.
The example below searches for three consecutive letter o, but the third o is optional.

```
gert@ubdesk:~$ cat alphabet
a
ab
abc
abcd
abcde
```

```
gert@ubdesk:~$ grep -E 'abcd?' alphabet
abc
abcd
abcde
```

```
gert@ubuntu:~$ cat list2
ll
lol
lool
loool
looool
gert@ubuntu:~$ grep -E 'ooo?' list2
lool
loool
looool
gert@ubuntu:~$ cat list2 | sed -r 's/ooo?/A/'
ll
lol
lAl
lAl
lAol
```

exactly n times

You can demand an exact number of times the previous has to occur.
This example wants exactly three o's.

```
gert@ubuntu:~$ cat list2
ll
lol
lool
loool
looool
gert@ubuntu:~$ grep -E 'o{3}' list2
loool
looool
gert@ubuntu:~$ grep -E 'lo{3}l' list2
loool
gert@ubuntu:~$ cat list2 | sed -r 's/o{3}/A/'
ll
lol
lool
lAl
lAol
gert@ubuntu:~$
```

between n and m times

And here we demand exactly from minimum 2 to maximum 3 times.

```
gert@ubuntu:~$ cat list2
ll
lol
lool
loool
looool
gert@ubuntu:~$ grep -E 'lo{2,3}l' list2
lool
loool
gert@ubuntu:~$ grep 'lo\{2,3\}l' list2
lool
loool
gert@ubuntu:~$ cat list2 | sed 's/lo\{2,3\}l/gone/'
ll
lol
gone
gone
looool
gert@ubuntu:~$ cat list2 | sed -r 's/lo{2,3}l/gone/'
ll
```

lol
gone
gone
looool
gert@ubuntu:~$

bash history

The **bash shell** can also interpret some regular expressions.
This example shows how to manipulate the exclamation mask history feature of the bash shell.

```
gert@ubuntu:~$ mkdir hist
gert@ubuntu:~$ cd hist/
gert@ubuntu:~/hist$ touch file1 file2 file3
gert@ubuntu:~/hist$ ls -l file1
-rw-r--r-- 1 gert gert 0 Apr 15 22:07 file1
gert@ubuntu:~/hist$ !l
ls -l file1
-rw-r--r-- 1 gert gert 0 Apr 15 22:07 file1
gert@ubuntu:~/hist$ !l:s/1/3/
ls -l file3
-rw-r--r-- 1 gert gert 0 Apr 15 22:07 file3
gert@ubuntu:~/hist$
```

This also works with the history numbers in bash.

```
gert@ubuntu:~/hist$ history 6
 2089  mkdir hist
 2090  cd hist/
 2091  touch file1 file2 file3
 2092  ls -l file1
 2093  ls -l file3
 2094  history 6
gert@ubuntu:~/hist$ !2092
ls -l file1
-rw-r--r-- 1 gert gert 0 Apr 15 22:07 file1
gert@ubuntu:~/hist$ !2092:s/1/2/
ls -l file2
-rw-r--r-- 1 gert gert 0 Apr 15 22:07 file2
gert@ubuntu:~/hist$
```

Chapter 20. Introduction to vi

The **vi** editor is installed on almost every Unix system. Linux will very often install **vim** (**vi improved**) which is similar. Every system administrator should know **vi(m)**, because it is an easy tool to solve problems.
The **vi** editor is not intuitive, but once you get to know it, **vi** becomes a very powerful application. Most Linux distributions will include the **vimtutor** which is a 45 minute lesson in **vi(m)**.

command mode and insert mode

The vi editor starts in **command mode**. In command mode, you can type commands. Some commands will bring you into **insert mode**. In insert mode, you can type text. The **escape key** will return you to command mode.

Table 22.1. getting to command mode

key	action
Esc	set vi(m) in command mode.

start typing (a A i I o O)

The difference between a A i I o and O is the location where you can start typing. a will append after the current character and A will append at the end of the line. i will insert before the current character and I will insert at the beginning of the line. o will put you in a new line after the current line and O will put you in a new line before the current line.

Table 22.2. switch to insert mode

command	action
a	start typing after the current character
A	start typing at the end of the current line
i	start typing before the current character
I	start typing at the start of the current line
o	start typing on a new line after the current line
O	start typing on a new line before the current line

replace and delete a character (r x X)

When in command mode (it doesn't hurt to hit the escape key more than once) you can use the x key to delete the current character. The big X key (or shift x) will delete the character left of the cursor. Also when in command mode, you can use the r key to replace one single character. The r key will bring you in insert mode for just one key press, and will return you immediately to command mode.

Table 22.3. replace and delete

command	action
x	delete the character below the cursor
X	delete the character before the cursor
r	replace the character below the cursor
p	paste after the cursor (here the last deleted character)
xp	switch two characters

undo and repeat (u .)

When in command mode, you can undo your mistakes with u. You can do your mistakes twice with . (in other words, the . will repeat your last command).

Table 22.4. undo and repeat

command	action
u	undo the last action
. (dot)	repeat the last action

cut, copy and paste a line (dd yy p P)

When in command mode, dd will cut the current line. yy will copy the current line. You can paste the last copied or cut line after (p) or before (P) the current line.

Table 22.5. cut, copy and paste a line

command	action
dd	cut the current line
yy	(yank yank) copy the current line
p	paste after the current line
P	paste before the current line

cut, copy and paste lines (3dd 2yy)

When in command mode, before typing dd or yy, you can type a number to repeat the command a number of times. Thus, 5dd will cut 5 lines and 4yy will copy (yank) 4 lines. That last one will be noted by vi in the bottom left corner as "4 line yanked".

Table 22.6. cut, copy and paste lines

command	action
3dd	cut three lines
4yy	copy four lines

start and end of a line (0 or ^ and $)

When in command mode, the 0 and the caret ^ will bring you to the start of the current line, whereas the $ will put the cursor at the end of the current line. You can add 0 and $ to the d command, d0 will delete every character between the current character and the start of the line. Likewise d$ will delete everything from the current character till the end of the line. Similarly y0 and y$ will yank till start and end of the current line.

Table 22.7. start and end of line

command	action
0	jump to start of current line
^	jump to start of current line
$	jump to end of current line

d0	delete until start of line
d$	delete until end of line

join two lines (J) and more

When in command mode, pressing **J** will append the next line to the current line. With **yyp** you duplicate a line and with **ddp** you switch two lines.

Table 22.8. join two lines

command	action
J	join two lines
yyp	duplicate a line
ddp	switch two lines

words (w b)

When in command mode, **w** will jump to the next word and **b** will move to the previous word. w and b can also be combined with d and y to copy and cut words (dw db yw yb).

Table 22.9. words

command	action
w	forward one word
b	back one word
3w	forward three words
dw	delete one word
yw	yank (copy) one word
5yb	yank five words back
7dw	delete seven words

save (or not) and exit (:w :q :q!)

Pressing the colon : will allow you to give instructions to vi (technically speaking, typing the colon will open the **ex** editor). **:w** will write (save) the file, **:q** will quit an unchanged file without saving, and **:q!** will quit vi discarding any changes. **:wq** will save and quit and is the same as typing **ZZ** in command mode.

Table 22.10. save and exit vi

command	action
:w	save (write)
:w fname	save as fname
:q	quit
:wq	save and quit
ZZ	save and quit
:q!	quit (discarding your changes)
:w!	save (and write to non-writable file!)

The last one is a bit special. With **:w! vi** will try to **chmod** the file to get write permission (this works when you are the owner) and will **chmod** it back when the write succeeds. This should always work when you are root (and the file system is writable).

Searching (/ ?)

When in command mode typing / will allow you to search in vi for strings (can be a regular expression). Typing /foo will do a forward search for the string foo and typing ?bar will do a backward search for bar.

Table 22.11. searching

command	action
/string	forward search for string
?string	backward search for string
n	go to next occurrence of search string

/^string	forward search string at beginning of line
/string$	forward search string at end of line
/br[aeio]l	search for bral brel bril and brol
/\<he\>	search for the word **he** (and not for **he**re or t**he**)

replace all (:1,$ s/foo/bar/g)

To replace all occurrences of the string foo with bar, first switch to ex mode with : . Then tell vi which lines to use, for example 1,$ will do the replace all from the first to the last line. You can write 1,5 to only process the first five lines. The s/foo/bar/g will replace all occurrences of foo with bar.

Table 22.12. replace

command	action
:4,8 s/foo/bar/g	replace foo with bar on lines 4 to 8
:1,$ s/foo/bar/g	replace foo with bar on all lines

reading files (:r :r !cmd)

When in command mode, :r foo will read the file named foo, :r !foo will execute the command foo. The result will be put at the current location. Thus :r !ls will put a listing of the current directory in your text file.

Table 22.13. read files and input

command	action
:r fname	(read) file fname and paste contents
:r !cmd	execute cmd and paste its output

abbreviations

With **:ab** you can put abbreviations in vi. Use **:una** to undo the abbreviation.

Table 22.16. abbreviations

command	action
:ab str long string	abbreviate **str** to be 'long string'
:una str	un-abbreviate str

key mappings

Similarly to their abbreviations, you can use mappings with **:map** for command mode and **:map!** for insert mode.
This example shows how to set the F6 function key to toggle between **set number** and **set nonumber**. The <bar> separates the two commands, **set number!** toggles the state and **set number?** reports the current state.

```
:map <F6> :set number!<bar>set number?<CR>
```

setting options

Some options that you can set in vim.

```
:set number  ( also try :se nu )
:set nonumber
:syntax on
:syntax off
:set all  (list all options)
:set tabstop=8
:set tx   (CR/LF style endings)
:set notx
```

You can set these options (and much more) in **~/.vimrc** for vim or in **~/.exrc** for standard vi.

```
gert@ubuntu:~$ cat ~/.vimrc
set number
set tabstop=8
set textwidth=78
map <F6> :set number!<bar>set number?<CR>
gert@ubuntu:~$
```

Chapter 21. users

This chapter will teach you how to identify your user account on a Unix computer using commands like **whoami**, **id**, and more.

In a second part you will learn how to become another user with the **su** command.
And you will learn how to run a program as another user with **sudo**.

Then you will see how to use **useradd**, **usermod** and **userdel** to create, modify and remove user accounts.

Then we will tell you more about passwords for local users.
Three methods for setting passwords are explained; using the **passwd** command, using **openssl passwd**, and using the crypt function in a C program.

The chapter will also discuss password settings and disabling, suspending or locking accounts.

Logged on users have a number of preset (and customized) aliases, variables, and functions, but where do they come from ? The **shell** uses a number of startup files that are executed (or rather **sourced**) whenever the shell is invoked. What follows is an overview of startup scripts.

You will sometimes need root access on a Linux computer to complete this chapter.

whoami

The **whoami** command tells you your username.

```
gert@ubuntu:~$ whoami
gert
gert@ubuntu:~$
```

who

The **who** command will give you information about who is logged on the system.

```
gert@ubuntu:~$ who
root     pts/0        2014-10-10 23:07 (10.104.33.101)
gert     pts/1        2014-10-10 23:30 (10.104.33.101)
laura    pts/2        2014-10-10 23:34 (10.104.33.96)
tania    pts/3        2014-10-10 23:39 (10.104.33.91)
gert@ubuntu:~$
```

w

The **w** command shows you who is logged on and what they are doing.

```
gert@ubuntu:~$ w
 23:34:07 up 31 min,  2 users,  load average: 0.00, 0.01, 0.02
USER     TTY        LOGIN@   IDLE   JCPU   PCPU WHAT
root     pts/0     23:07   15.00s  0.01s  0.01s top
gert     pts/1     23:30    7.00s  0.00s  0.00s w
gert@ubuntu:~$
```

id

The **id** command will give you your user id, primary group id, and a list of the groups that you belong to.

```
gert@ubuntu:~$ id
uid=1000(gert) gid=1000(gert) groups=1000(gert)
```

On RHEL/CentOS you will also get **SELinux** context information with this command.

```
root@ubuntu:~# id
uid=0(root) gid=0(root) groups=0(root)
context=unconfined_u:unconfined_r\
:unconfined_t:s0-s0:c0.c1023
```

su to another user

The **su** command allows a user to run a shell as another user.

```
laura@ubuntu:~$ su tania
Password:
tania@ubuntu:/home/laura$
```

su to root

Yes you can also **su** to become **root**, when you know the **root password**.

```
laura@ubuntu:~$ su root
Password:
root@ubuntu:/home/laura#
```

su as root

You need to know the password of the user you want to substitute to, unless your are logged in as **root**. The **root** user can become any existing user without knowing that user's password.

```
root@ubuntu:~# id
uid=0(root) gid=0(root) groups=0(root)
root@ubuntu:~# su - valentina
valentina@ubuntu:~$
```

su - $username

By default, the **su** command maintains the same shell environment. To become another user and also get the target user's environment, issue the **su -** command followed by the target username.

```
root@ubuntu:~# su laura
laura@ubuntu:/root$ exit
exit
root@ubuntu:~# su - laura
laura@ubuntu:~$ pwd
/home/laura
```

su -

When no username is provided to **su** or **su -**, the command will assume **root** is the target.
(This only works if the root user has a password! On Ubuntu this isn't by default.)

```
tania@ubuntu:~$ su -
Password:
root@ubuntu:~#
```

run a program as another user

The sudo program allows a user to start a program with the credentials of another user. Before this works, the system administrator has to set up the **/etc/sudoers** file. This can be useful to delegate administrative tasks to another user (without giving the root password).
The screenshot below shows the usage of **sudo**. User **gert** received the right to run **useradd** with the credentials of **root**. This allows **gert** to create new users on the system without becoming **root** and without knowing the **root password**.
First the command fails for **gert**.

```
gert@ubuntu:~$ /usr/sbin/useradd -m valentina
useradd: Permission denied.
useradd: cannot lock /etc/passwd; try again later.
```

But with **sudo** it works.

```
gert@ubuntu:~$ sudo /usr/sbin/useradd -m valentina
[sudo] password for gert:
gert@ubuntu:~$
```

visudo

Check the man page of **visudo** before playing with the **/etc/sudoers** file. Editing the **sudoers** is out of scope for this fundamentals book.

```
gert@ubuntu:~$ apropos visudo
visudo               (8)  - edit the sudoers file
gert@ubuntu:~$
```

sudo su -

On some Linux systems like Ubuntu and Xubuntu, the **root** user does not have a password set. This means that it is not possible to login as **root** (extra security). To perform tasks as **root**, the first user is given all **sudo rights** via the **/etc/sudoers**. In fact all users that are members of the admin group can use sudo to run all commands as root.

```
root@ubuntu:~# grep admin /etc/sudoers
# Members of the admin group may gain root privileges
%admin ALL=(ALL) ALL
```

The end result of this is that the user can type **sudo su -** and become root without having to enter the root password. The sudo command does require you to enter your own password. Thus the password prompt in the screenshot below is for sudo, not for su.

```
gert@ubuntu:~$ sudo su -
Password:
root@ubuntu:~#
```

sudo logging

Using **sudo** without authorization will result in a severe warning:

```
gert@ubuntu:~$ sudo su -

We trust you have received the usual lecture from the local System
Administrator. It usually boils down to these three things:

    #1) Respect the privacy of others.
    #2) Think before you type.
    #3) With great power comes great responsibility.

[sudo] password for gert:
gert is not in the sudoers file.  This incident will be reported.
gert@ubuntu:~$
```

The root user can see this in the **/var/log/secure** on Red Hat and in **/var/log/auth.log** on Debian.

```
root@ubuntu:~# cat /var/log/auth.log | grep sudo | tr -s ' '
Dec 18 16:03:42 ubuntu sudo: gert : user NOT in sudoers ; TTY=pts/0
; PWD=\
/home/gert ; USER=root ; COMMAND=/bin/su -
root@ubuntu:~#
```

user management

User management on Linux can be done in three complementary ways. You can use the **graphical** tools provided by your distribution. These tools have a look and feel that depends on the distribution. If you are a novice Linux user on your home system, then use the graphical tool that is provided by your distribution. This will make sure that you do not run into problems.
Another option is to use **command line tools** like useradd, usermod, gpasswd, passwd and others. Server administrators are likely to use these tools, since they are familiar and very similar across many different distributions. This chapter will focus on these command line tools.
A third and rather extremist way is to **edit the local configuration files** directly using vi (or vipw/vigr). Do not attempt this as a novice on production systems!

/etc/passwd

The local user database on Linux (and on most Unixes) is **/etc/passwd**.

```
root@ubuntu:~# tail /etc/passwd
inge:x:518:524:art dealer:/home/inge:/bin/ksh
ann:x:519:525:flute player:/home/ann:/bin/bash
frederik:x:520:526:rubius poet:/home/frederik:/bin/bash
steven:x:521:527:roman emperor:/home/steven:/bin/bash
pascale:x:522:528:artist:/home/pascale:/bin/ksh
geert:x:524:530:kernel developer:/home/geert:/bin/bash
wim:x:525:531:master damuti:/home/wim:/bin/bash
sandra:x:526:532:radish stresser:/home/sandra:/bin/bash
annelies:x:527:533:sword fighter:/home/annelies:/bin/bash
laura:x:528:534:art dealer:/home/laura:/bin/ksh
```

As you can see, this file contains seven columns separated by a colon. The columns contain the username, an x, the user id, the primary group id, a description, the name of the home directory, and the login shell.
More information can be found by typing **man 5 passwd**.

```
root@ubuntu:~# man 5 passwd
```

root

The **root** user also called the **superuser** is the most powerful account on your Linux system. This user can do almost anything, including the creation of other users. The root user always has userid 0 (regardless of the name of the account).

```
root@ubuntu:~# head -1 /etc/passwd
root:x:0:0:root:/root:/bin/bash
```

useradd

You can add users with the **useradd** command. The example below shows how to add a user named yanina (last parameter) and at the same time forcing the creation of the home directory (-m), setting the name of the home directory (-d), and setting a description (-c).

```
root@ubuntu:~# useradd -m -d /home/yanina -c "yanina wickmayer"
yanina
root@ubuntu:~# tail -1 /etc/passwd
yanina:x:529:535:yanina wickmayer:/home/yanina:/bin/bash
```

The user named yanina received userid 529 and **primary group** id 535.

/etc/default/useradd

Both Red Hat Enterprise Linux and Debian/Ubuntu have a file called /etc/default/useradd that contains some default user options. Besides using cat to display this file, you can also use useradd -D.

```
root@ubuntu:~# useradd -D
GROUP=100
HOME=/home
INACTIVE=-1
EXPIRE=
SHELL=/bin/bash
SKEL=/etc/skel
```

userdel

You can delete the user yanina with **userdel**. The -r option of userdel will also remove the home directory.

```
root@ubuntu:~# userdel -r yanina
```

usermod

You can modify the properties of a user with the **usermod** command. This example uses **usermod** to change the description of the user harry.

```
root@ubuntu:~# tail -1 /etc/passwd
harry:x:1003:1003:harry potter:/home/harry:/bin/bash
root@ubuntu:~# usermod -c 'wizard' harry
root@ubuntu:~# tail -1 /etc/passwd
harry:x:1003:1003:wizard:/home/harry:/bin/bash
```

creating home directories

The easiest way to create a home directory is to supply the **-m** option with **useradd** (it is likely set as a default option on Linux).
A less easy way is to create a home directory manually with **mkdir** which also requires setting the owner and the permissions on the directory with **chmod** and **chown** (both commands are discussed in detail in another chapter).

```
root@ubuntu:~# mkdir /home/laura
root@ubuntu:~# chown laura:laura /home/laura
root@ubuntu:~# chmod 700 /home/laura
root@ubuntu:~# ls -ld /home/laura/
drwx------ 2 laura laura 4096 Jun 24 15:17 /home/laura/
```

/etc/skel/

When using **useradd** the **-m** option, the **/etc/skel/** directory is copied to the newly created home directory. The **/etc/skel/** directory contains some (usually hidden) files that contain profile settings and default values for applications. In this way **/etc/skel/** serves as a default home directory and as a default user profile.

```
root@ubuntu:~# ls -la /etc/skel/
total 48
drwxr-xr-x  2 root root  4096 Apr  1 00:11 .
drwxr-xr-x 97 root root 12288 Jun 24 15:36 ..
-rw-r--r--  1 root root    24 Jul 12  2006 .bash_logout
-rw-r--r--  1 root root   176 Jul 12  2006 .bash_profile
-rw-r--r--  1 root root   124 Jul 12  2006 .bashrc
```

deleting home directories

The -r option of **userdel** will make sure that the home directory is deleted together with the user account.

```
root@ubuntu:~# ls -ld /home/wim/
drwx------ 2 wim wim 4096 Jun 24 15:19 /home/wim/
root@ubuntu:~# userdel -r wim
root@ubuntu:~# ls -ld /home/wim/
ls: /home/wim/: No such file or directory
```

login shell

The **/etc/passwd** file specifies the **login shell** for the user. In the screenshot below you can see that user annelies will log in with the **/bin/bash** shell, and user laura with the **/bin/ksh** shell.

```
root@ubuntu:~# tail -2 /etc/passwd
annelies:x:527:533:sword fighter:/home/annelies:/bin/bash
laura:x:528:534:art dealer:/home/laura:/bin/ksh
```

You can use the usermod command to change the shell for a user.

```
root@ubuntu:~# usermod -s /bin/bash laura
root@ubuntu:~# tail -1 /etc/passwd
laura:x:528:534:art dealer:/home/laura:/bin/bash
```

chsh

Users can change their login shell with the **chsh** command. First, user harry obtains a list of available shells (he could also have done a **cat /etc/shells**) and then changes his login shell to the **Korn shell** (/bin/ksh). At the next login, harry will default into ksh instead of bash.

```
[laura@centos7 ~]$ chsh -l
/bin/sh
/bin/bash
/sbin/nologin
/usr/bin/sh
/usr/bin/bash
/usr/sbin/nologin
/bin/ksh
/bin/tcsh
/bin/csh
[laura@centos7 ~]$
```

Note that the **-l** option does not exist on Debian and that the above screenshot assumes that **ksh** and **csh** shells are installed.
On **Ubuntu** you can use the command **cat /etc/shells**

The screenshot below shows how **laura** can change her default shell (active on next login).

```
[laura@centos7 ~]$ chsh -s /bin/ksh
Changing shell for laura.
Password:
Shell changed.
```

passwd

Passwords of users can be set with the **passwd** command. Users will have to provide their old password before twice entering the new one.

```
[tania@centos7 ~]$ passwd
Changing password for user tania.
Changing password for tania.
(current) UNIX password:
New password:
BAD PASSWORD: The password is shorter than 8 characters
New password:
BAD PASSWORD: The password is a palindrome
New password:
BAD PASSWORD: The password is too similar to the old one
passwd: Have exhausted maximum number of retries for service
```

As you can see, the passwd tool will do some basic verification to prevent users from using too simple passwords. The **root** user does not have to follow these rules (there will be a warning though). The **root** user also does not have to provide the old password before entering the new password twice.

```
root@ubuntu:~# passwd tania
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
```

shadow file

User passwords are encrypted and kept in **/etc/shadow**. The /etc/shadow file is read only and can only be read by root. We will see in the file permissions section how it is possible for users to change their password. For now, you will have to know that users can change their password with the **/usr/bin/passwd** command.

```
root@ubuntu:~# tail -4 /etc/shadow
gert:$6$ikp2Xta5BT.Tml.p$2TZjNnOYNNQKpwLJqoGJbVsZG5/Fti8ovBRd.VzRbi
DSl7TEq\
IaSMH.TeBKnTS/SjlMruW8qffC0JNORW.BTW1:16338:0:99999:7:::
tania:$6$8Z/zovxj$9qvoqT8i9KIrmN.k4EQwAF5ryz5yzNwEvYjAa9L5XVXQu.z4D
lpvMREH\
eQpQzvRnqFdKkVj17H5ST.c79HDZw0:16356:0:99999:7:::
laura:$6$glDuTY5e$/NYYWLxfHgZFWeoujaXSMcR.Mz.lGOxtcxFocFVJNb98nbTPh
WFXfKWG\
SyYh1WCv6763Wq54.w24Yr3uAZBOm/:16356:0:99999:7:::
valentina:$6$jrZa6PVI$1uQgqR6En9mZB6mKJ3LXRB4CnFko6LRhbh.v4iqUk9MVr
eui1lv7\
GxHOUDSKA0N55ZRNhGHa6T2ouFnVno/0o1:16356:0:99999:7:::
root@ubuntu:~#
```

The **/etc/shadow** file contains nine colon separated columns. The nine fields contain (from left to right) the user name, the encrypted password (note that only inge and laura have an encrypted password), the day the password was last changed (day 1 is January 1, 1970), number of days the password must be left unchanged, password expiry day, warning number of days before password expiry, number of days after expiry before disabling the account, and the day the account was disabled (again, since 1970). The last field has no meaning yet.
All the passwords in the screenshot above are hashes of **hunter2**.

encryption with passwd

Passwords are stored in an encrypted format. This encryption is done by the **crypt** function. The easiest (and recommended) way to add a user with a password to the system is to add the user with the **useradd -m user** command, and then set the user's password with **passwd**.

```
root@ubuntu:~# useradd -m xavier
root@ubuntu:~# passwd xavier
Changing password for user xavier.
New UNIX password:
Retype new UNIX password:
passwd: all authentication tokens updated successfully.
root@ubuntu:~#
```

encryption with openssl

Another way to create users with a password is to use the -p option of useradd, but that option requires an encrypted password. You can generate this encrypted password with the **openssl passwd** command.
The **openssl passwd** command will generate several distinct hashes for the same password, for this it uses a **salt**.

```
gert@ubuntu:~$ openssl passwd hunter2
86jcUNlnGDFpY
gert@ubuntu:~$ openssl passwd hunter2
Yj7mDO9OAnvq6
gert@ubuntu:~$ openssl passwd hunter2
YqDcJeGoDbzKA
gert@ubuntu:~$
```

This **salt** can be chosen and is visible as the first two characters of the hash.

```
gert@ubuntu:~$ openssl passwd -salt 42 hunter2
42ZrbtP1Ze8G.
gert@ubuntu:~$ openssl passwd -salt 42 hunter2
42ZrbtP1Ze8G.
gert@ubuntu:~$ openssl passwd -salt 42 hunter2
42ZrbtP1Ze8G.
gert@ubuntu:~$
```

This example shows how to create a user with password.

```
root@ubuntu:~# useradd -m -p $(openssl passwd hunter2) mohamed
```

Note that this command puts the password in your command history!

encryption with crypt

A third option is to create your own C program using the crypt function, and compile this into a command.

```
gert@ubuntu:~$ cat MyCrypt.c
#include <stdio.h>
#define __USE_XOPEN
#include <unistd.h>

int main(int argc, char** argv)
{
 if(argc==3)
   {
      printf("%s\n", crypt(argv[1],argv[2]));
   }
   else
   {
      printf("Usage: MyCrypt $password $salt\n" );
   }
  return 0;
}
```

This little program can be compiled with **gcc** like this.

```
gert@ubuntu:~$ gcc MyCrypt.c -o MyCrypt -lcrypt
```

To use it, we need to give two parameters to MyCrypt. The first is the unencrypted password, the second is the salt. The salt is used to perturb the encryption algorithm in one of 4096 different ways. This variation prevents two users with the same password from having the same entry in **/etc/shadow**.

```
gert@ubuntu:~$ ./MyCrypt hunter2 42
42ZrbtP1Ze8G.
gert@ubuntu:~$ ./MyCrypt hunter2 33
33d6taYSiEUXI
```

Did you notice that the first two characters of the password are the **salt**?
The standard output of the crypt function is using the DES algorithm which is old and can be cracked in minutes. A better method is to use **md5** passwords which can be recognized by a salt starting with 1.

```
gert@ubuntu:~$ ./MyCrypt hunter2 '$1$42'
$1$42$7l6Y3xT5282XmZrtDOF9f0
gert@ubuntu:~$ ./MyCrypt hunter2 '$6$42'
$6$42$OqFFAVnI3gTSYG0yI9TZWX9cpyQzwIop7HwpG1LlEsNBiMr4w6OvLX1KDa./U
pwXfrFk1i...
```

The **md5** salt can be up to eight characters long. The salt is displayed in **/etc/shadow** between the second and third $, so never use the password as the salt!

```
gert@ubuntu:~$ ./MyCrypt hunter2 '$1$hunter2'
$1$hunter2$YVxrxDmidq7Xf8Gdt6qM2.
```

/etc/login.defs

The **/etc/login.defs** file contains some default settings for user passwords like password aging and length settings. (You will also find the numerical limits of user ids and group ids and whether or not a home directory should be created by default).

```
root@ubuntu:~# grep PASS /etc/login.defs
#  PASS_MAX_DAYS   Maximum number of days a password may be used.
#  PASS_MIN_DAYS   Minimum number of days allowed between password
changes.
#  PASS_WARN_AGE   Number of days warning given before a password
expires.
PASS_MAX_DAYS   99999
PASS_MIN_DAYS   0
PASS_WARN_AGE   7
#PASS_CHANGE_TRIES
#PASS_ALWAYS_WARN
#PASS_MIN_LEN
#PASS_MAX_LEN
# NO_PASSWORD_CONSOLE
root@ubuntu:~#
```

chage

The **chage** command can be used to set an expiration date for a user account (-E), set a minimum (-m) and maximum (-M) password age, a password expiration date, and set the number of warning days before the password expiration date. Much of this functionality is also available from the **passwd** command. The **-l** option of chage will list these settings for a user.

```
root@ubuntu:~# chage -l gert
Last password change                                    : Mar 27,
2014
Password expires                                        : never
Password inactive                                       : never
Account expires                                         : never
Minimum number of days between password change          : 0
Maximum number of days between password change          : 99999
Number of days of warning before password expires       : 7
root@ubuntu:~#
```

disabling a password

Passwords in **/etc/shadow** cannot begin with an exclamation mark. When the second field in **/etc/passwd** starts with an exclamation mark, then the password can not be used.
Using this feature is often called **locking**, **disabling**, or **suspending** a user account. Besides **vi** (or vipw) you can also accomplish this with **usermod**.
The first command in the next screenshot will show the hashed password of **laura** in **/etc/shadow**. The next command disables the password of **laura**, making it impossible for Laura to authenticate using this password.

```
root@ubuntu:~# grep laura /etc/shadow | cut -c1-70
laura:$6$JYj4JZqp$stwwWACp3OtE1R2aZuE87j.nbW.puDkNUYVk7mCHfCVMa3CoD
UJV
root@ubuntu:~# usermod -L laura
```

As you can see below, the password hash is simply preceded with an exclamation mark.

```
root@ubuntu:~# grep laura /etc/shadow | cut -c1-70
laura:!$6$JYj4JZqp$stwwWACp3OtE1R2aZuE87j.nbW.puDkNUYVk7mCHfCVMa3Co
DUJ
root@ubuntu:~#
```

The root user (and users with **sudo** rights on **su**) still will be able to **su** into the **laura** account (because the password is not needed here). Also note that **laura** will still be able to login if she has set up passwordless ssh!

```
root@ubuntu:~# su - laura
laura@ubuntu:~$
```

You can unlock the account again with **usermod -U**.

```
root@ubuntu:~# usermod -U laura
root@ubuntu:~# grep laura /etc/shadow | cut -c1-70
laura:$6$JYj4JZqp$stwwWACp3OtE1R2aZuE87j.nbW.puDkNUYVk7mCHfCVMa3CoD
UJV
```

Watch out for tiny differences in the command line options of **passwd**, **usermod**, and **useradd** on different Linux distributions. Verify the local files when using features like **"disabling, suspending, or locking"** on user accounts and their passwords.

editing local files

If you still want to manually edit the **/etc/passwd** or **/etc/shadow**, after knowing these commands for password management, then use **vipw** instead of vi(m) directly. The **vipw** tool will do proper locking of the file.

```
root@ubuntu:~# vipw /etc/passwd
vipw: the password file is busy (/etc/ptmp present)
```

system profile

Both the **bash** and the **ksh** shell will verify the existence of **/etc/profile** and **source** it if it exists. When reading this script, you will notice (both on Debian and on Red Hat Enterprise Linux) that it builds the PATH environment variable (among others). The script might also change the PS1 variable, set the HOSTNAME and execute even more scripts like **/etc/inputrc**
This screenshot uses grep to show PATH manipulation in **/etc/profile** on Debian.

```
root@ubuntu:~# grep PATH /etc/profile

PATH="/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin"
  PATH="/usr/local/bin:/usr/bin:/bin:/usr/local/games:/usr/games"
export PATH
root@ubuntu:~#
```

This screenshot uses grep to show PATH manipulation in **/etc/profile** on RHEL7/CentOS7.

```
root@ubuntu:~# grep PATH /etc/profile
    case ":${PATH}:" in
                PATH=$PATH:$1
                PATH=$1:$PATH
export PATH USER LOGNAME MAIL HOSTNAME HISTSIZE HISTCONTROL
root@ubuntu:~#
```

The **root user** can use this script to set aliases, functions, and variables for every user on the system.

~/.bash_profile

When this file exists in the home directory, then **bash** will source it. On Debian Linux 5/6/7 this file does not exist by default.
RHEL7/CentOS7 uses a small **~/.bash_profile** where it checks for the existence of **~/.bashrc** and then sources it. It also adds $HOME/bin to the $PATH variable.

```
root@ubuntu:~# cat /home/gert/.bash_profile
# .bash_profile

# Get the aliases and functions
if [ -f ~/.bashrc ]; then
        . ~/.bashrc
fi

# User specific environment and startup programs

PATH=$PATH:$HOME/.local/bin:$HOME/bin

export PATH
root@ubuntu:~#
```

~/.bash_login

When **.bash_profile** does not exist, then **bash** will check for **~/.bash_login** and source it.
Neither Debian nor Red Hat have this file by default.

~/.profile

When neither **~/.bash_profile** and **~/.bash_login** exist, then bash will verify the existence of **~/.profile** and execute it. This file does not exist by default on Red Hat.
On Debian this script can execute **~/.bashrc** and will add $HOME/bin to the $PATH variable.

```
root@ubuntu:~# tail -11 /home/gert/.profile
if [ -n "$BASH_VERSION" ]; then
    # include .bashrc if it exists
    if [ -f "$HOME/.bashrc" ]; then
        . "$HOME/.bashrc"
    fi
fi

# set PATH so it includes user's private bin if it exists
if [ -d "$HOME/bin" ] ; then
    PATH="$HOME/bin:$PATH"
fi
```

RHEL/CentOS does not have this file by default.

~/.bashrc

The **~/.bashrc** script is often sourced by other scripts. Let us take a look at what it does by default.
Red Hat uses a very simple **~/.bashrc**, checking for **/etc/bashrc** and sourcing it. It also leaves room for custom aliases and functions.

```
root@ubuntu:~# cat /home/gert/.bashrc
# .bashrc

# Source global definitions
if [ -f /etc/bashrc ]; then
        . /etc/bashrc
fi

# Uncomment the following line if you don't like systemctl's
auto-paging feature:
# export SYSTEMD_PAGER=

# User specific aliases and functions
```

On Debian this script is quite a bit longer and configures $PS1, some history variables and a number af active and inactive aliases.

```
root@ubuntu:~# wc -l /home/gert/.bashrc
110 /home/gert/.bashrc
```

~/.bash_logout

When exiting **bash**, it can execute **~/.bash_logout**.
Debian use this opportunity to clear the console screen.

```
serena@ubuntu:~$ cat .bash_logout
# ~/.bash_logout: executed by bash(1) when login shell exits.

# when leaving the console clear the screen to increase privacy

if [ "$SHLVL" = 1 ]; then
    [ -x /usr/bin/clear_console ] && /usr/bin/clear_console -q
fi
```

Red Hat Enterprise Linux 5 will simple call the **/usr/bin/clear** command in this script.

```
serena@ubuntu:~$ cat .bash_logout
# ~/.bash_logout

/usr/bin/clear
```

Red Hat Enterprise Linux 6 and 7 create this file, but leave it empty (except for a comment).

```
gert@ubuntu:~$ cat .bash_logout
# ~/.bash_logout
```

Debian overview

Below is a table overview of when Debian is running any of these bash startup scripts.

Table 30.1. Debian User Environment

script	su	su-	ssh	gdm
~./bashrc	no	yes	yes	yes
~/.profile	no	yes	yes	yes
/etc/profile	no	yes	yes	yes
/etc/bash.bashrc	yes	no	no	yes

RHEL overview

Below is a table overview of when Red Hat Enterprise Linux 5 is running any of these bash startup scripts.

Table 30.2. Red Hat User Environment

script	su	su-	ssh	gdm
~./bashrc	yes	yes	yes	yes
~/.bash_profile	no	yes	yes	yes
/etc/profile	no	yes	yes	yes

/etc/bashrc	yes	yes	yes	yes

Chapter 22. groups

Users can be listed in **groups**. Groups allow you to set permissions on the group level instead of having to set permissions for every individual user.
Every Unix or Linux distribution will have a graphical tool to manage groups. Novice users are advised to use this graphical tool. More experienced users can use command line tools to manage users, but be careful: Some distributions do not allow the mixed use of GUI and CLI tools to manage groups (YaST in Novell Suse). Senior administrators can edit the relevant files directly with **vi** or **vigr**.

groupadd

Groups can be created with the **groupadd** command. The example below shows the creation of five (empty) groups.

```
root@ubuntu:~# groupadd tennis
root@ubuntu:~# groupadd football
root@ubuntu:~# groupadd snooker
root@ubuntu:~# groupadd formula1
root@ubuntu:~# groupadd salsa
```

group file

Users can be a member of several groups. Group membership is defined by the **/etc/group** file.

```
root@ubuntu:~# tail -5 /etc/group
tennis:x:1006:
football:x:1007:
snooker:x:1008:
formula1:x:1009:
salsa:x:1010:
root@ubuntu:~#
```

The first field is the group's name. The second field is the group's (encrypted) password (can be empty). The third field is the group identification or **GID**. The fourth field is the list of members, these groups have no members.

groups

A user can type the **groups** command to see a list of groups where the user belongs to.

```
harry@ubuntu:~$ groups
harry sports
harry@ubuntu:~$
```

usermod to add users to a Secundary (Supplementary) Group

Group membership can be modified with the useradd or **usermod** command.

```
root@ubuntu:~# usermod -a -G tennis inge
root@ubuntu:~# usermod -a -G tennis katrien
root@ubuntu:~# usermod -a -G salsa katrien
root@ubuntu:~# usermod -a -G snooker sandra
root@ubuntu:~# usermod -a -G formula1 annelies
root@ubuntu:~# tail -5 /etc/group
tennis:x:1006:inge,katrien
football:x:1007:
snooker:x:1008:sandra
formula1:x:1009:annelies
salsa:x:1010:katrien
root@ubuntu:~#
```

Be careful when using **usermod** to add users to groups. By default, the **usermod** command will **remove** the user from every group of which he is a member if the group is not listed in the command! Using the **-a** (append) switch prevents this behaviour.

usermod to specify a Primary (Login) Group for a user

The primary group will become the groupowner of every file or folder you create.
The Primary Group of a user can be changed with the **usermod** command.

```
root@ubuntu:~# usermod -g salsa inge
root@ubuntu:~# grep inge /etc/passwd
inge:x:1003:1010:art dealer:/home/inge:/bin/bash
root@ubuntu:~# grep salsa /etc/group
salsa:x:1010:katrien
root@ubuntu:~#
```

You change the **primary group** when using **usermod** with a **lower letter g**. This wil only make a modification in the passwd-file. Nothing will be changed in the group-file. In the password file you will see the groupnumber of the user. In the group file you see the name that correspondents with this group number.
You don't have to specify the **-a** (append) because a user can only have one primary group.

gpasswd

Group membership can also be modified with the **gpasswd** command.

With this command you can **add a user to a group**.

```
root@ubuntu:~# gpasswd -a gert tennis
Adding user gert to group tennis
root@ubuntu:~# grep tennis /etc/group
tennis:x:1006:inge,katrien,gert
```

With this command you can **remove a user from a group**.

```
root@ubuntu:~# gpasswd -d gert tennis
Removing user gert from group tennis
root@ubuntu:~# grep tennis /etc/group
tennis:x:1006:inge,katrien
```

groupmod

You can change the group name with the **groupmod** command.

```
root@ubuntu:~# groupmod -n darts snooker
root@ubuntu:~# tail -5 /etc/group
tennis:x:1006:inge,katrien
football:x:1007:
formula1:x:1009:annelies
salsa:x:1010:katrien
darts:x:1008:sandra
```

groupdel

You can permanently remove a group with the **groupdel** command.

```
root@ubuntu:~# groupdel tennis
root@ubuntu:~#
```

gpasswd

You can delegate control of group membership to another user with the **gpasswd** command. In the example below we delegate permissions to add and remove group members to serena for the sports group. Then we **su** to serena and add harry to the sports group.

```
root@ubuntu:~# gpasswd -A serena sports
root@ubuntu:~# su - serena
serena@ubuntu:~$ id harry
uid=516(harry) gid=520(harry) groups=520(harry)
serena@ubuntu:~$ gpasswd -a harry sports
Adding user harry to group sports
serena@ubuntu:~$ id harry
uid=516(harry) gid=520(harry) groups=520(harry),522(sports)
serena@ubuntu:~$ tail -1 /etc/group
sports:x:522:serena,venus,harry
serena@ubuntu:~$
```

Group administrators do not have to be a member of the group. They can remove themselves from a group, but this does not influence their ability to add or remove members.

```
serena@ubuntu:~$ gpasswd -d serena sports
Removing user serena from group sports
serena@ubuntu:~$ exit
```

Information about group administrators is kept in the **/etc/gshadow** file.

```
root@ubuntu:~# tail -1 /etc/gshadow
sports:!:serena:venus,harry
root@ubuntu:~#
```

To remove all group administrators from a group, use the **gpasswd** command to set an empty administrators list.

```
root@ubuntu:~# gpasswd -A "" sports
```

newgrp

You can start a **child shell** with a new temporary **primary group** using the **newgrp** command.

```
root@ubuntu:~# mkdir prigroup
root@ubuntu:~# cd prigroup/
root@ubuntu:~/prigroup# touch standard.txt
root@ubuntu:~/prigroup# ls -l
total 0
-rw-r--r--. 1 root root 0 Apr 13 17:49 standard.txt
root@ubuntu:~/prigroup# echo $SHLVL
1
root@ubuntu:~/prigroup# newgrp tennis
root@ubuntu:~/prigroup# echo $SHLVL
2
root@ubuntu:~/prigroup# touch newgrp.txt
root@ubuntu:~/prigroup# ls -l
total 0
-rw-r--r--. 1 root tennis 0 Apr 13 17:49 newgrp.txt
-rw-r--r--. 1 root root   0 Apr 13 17:49 standard.txt
root@ubuntu:~/prigroup# exit
exit
root@ubuntu:~/prigroup# echo $SHLVL
1
root@ubuntu:~/prigroup#
```

vigr

Similar to vipw, the **vigr** command can be used to manually edit the **/etc/group** file, since it will do proper locking of the file. Only experienced senior administrators should use **vi** or **vigr** to manage groups.

Chapter 23. standard file permissions

This chapter contains details about basic file security through **file ownership** and **file permissions**.

file ownership

user owner and group owner

The **users** and **groups** of a system can be locally managed in **/etc/passwd** and **/etc/group**, or they can be in a NIS, LDAP, or Samba domain. These users and groups can **own** files. Actually, every file has a **user owner** and a **group owner**, as can be seen in the following screenshot.

```
gert@ubuntu:~/owners$ ls -lh
total 636K
-rw-r--r-- 1 gert snooker 1.1K Apr  8 18:47 data.odt
-rw-r--r-- 1 gert gert    626K Apr  8 18:46 file1
-rw-r--r-- 1 root tennis   185 Apr  8 18:46 file2
-rw-rw-r-- 1 root root       0 Apr  8 18:47 stuff.txt
gert@ubuntu:~/owners$
```

User gert owns three files; file1 has gert as **user owner** and has the group gert as **group owner**, data.odt is **group owned** by the group snooker, file2 by the group tennis.
The last file is called stuff.txt and is owned by the root user and the root group.

listing user accounts

You can use the following command to list all local user accounts.

```
gert@ubuntu:~$ cut -d: -f1 /etc/passwd | column
root            ntp             sam             bert
naomi
daemon          mysql           tom             rino
matthias2
bin             gert            wouter          antonio
bram
sys             maarten         robrecht        simon
fabrice
sync            kevin           bilal           sven
chimene
games           yuri            dimitri         wouter2
messagebus
man             william         ahmed           tarik
roger
lp              yves            dylan           jan
frank
mail            kris            robin           ian
toon
news            hamid           matthias        ivan
rinus
uucp            vladimir        ben             azeddine
eddy
proxy           abiy            mike            eric
bram2
www-data        david           kevin2          kamel
keith
backup          chahid          kenzo           ischa
jesse
list            stef            aaron           bart
frederick
irc             joeri           lorenzo         omer
hans
gnats           glenn           jens            kurt
dries
nobody          yannick         ruben           steve
steve2
libuuid         christof        jelle           constantin
tomas
Debian-exim     george          stefaan         sam2
johan
statd           joost           marc            bjorn
tom2
sshd            arno            thomas          ronald
```

chgrp

You can change the group owner of a file using the **chgrp** command.

```
root@ubuntu:/home/gert/owners# ls -l file2
-rw-r--r-- 1 root tennis 185 Apr  8 18:46 file2
root@ubuntu:/home/gert/owners# chgrp snooker file2
root@ubuntu:/home/gert/owners# ls -l file2
-rw-r--r-- 1 root snooker 185 Apr  8 18:46 file2
root@ubuntu:/home/gert/owners#
```

chown

The user owner of a file can be changed with **chown** command.

```
root@ubuntu:/home/gert# ls -l FileForGert
-rw-r--r-- 1 root gert 0 2008-08-06 14:11 FileForGert
root@ubuntu:/home/gert# chown gert FileForGert
root@ubuntu:/home/gert# ls -l FileForGert
-rw-r--r-- 1 gert gert 0 2008-08-06 14:11 FileForGert
```

You can also use **chown** to change both the user owner and the group owner.

```
root@ubuntu:/home/gert# ls -l FileForGert
-rw-r--r-- 1 gert gert 0 2008-08-06 14:11 FileForGert
root@ubuntu:/home/gert# chown root:project42 FileForGert
root@ubuntu:/home/gert# ls -l FileForGert
-rw-r--r-- 1 root project42 0 2008-08-06 14:11 FileForGert
```

list of special files

When you use **ls -l**, for each file you can see ten characters before the user and group owner. The first character tells us the type of file. Regular files get a **-**, directories get a **d**, symbolic links are shown with an **l**, pipes get a **p**, character devices a **c**, block devices a **b**, and sockets an **s**.

Table 32.1. Unix special files

first character	file type
-	normal file
d	directory
l	symbolic link
p	named pipe
b	block device
c	character device
s	socket

Below a screenshot of a character device (the console) and a block device (the hard disk).

```
gert@ubuntu:~$ ls -ld /dev/console /dev/sda
crw-------   1 root root  5, 1 Mar 15 12:45 /dev/console
brw-rw----   1 root disk  8, 0 Mar 15 12:45 /dev/sda
```

And here you can see a directory, a regular file and a symbolic link.

```
gert@ubuntu:~$ ls -ld /etc /etc/hosts /etc/motd
drwxr-xr-x 128 root root 12288 Mar 15 18:34 /etc
-rw-r--r--   1 root root   372 Dec 10 17:36 /etc/hosts
lrwxrwxrwx   1 root root    13 Dec  5 10:36 /etc/motd ->
/var/run/motd
```

permissions

rwx

The nine characters following the file type denote the permissions in three triplets. A permission can be **r** for read access, **w** for write access, and **x** for execute. You need the **r** permission to list (ls) the contents of a directory. You need the **x** permission to enter (cd) a directory. You need the **w** permission to create files in or remove files from a directory.

Table 32.2. standard Unix file permissions

permission	on a file	on a directory
r (read)	read file contents (cat)	read directory contents (ls)
w (write)	change file contents (vi)	create files in (touch)
x (execute)	execute the file	enter the directory (cd)

three sets of rwx

We already know that the output of **ls -l** starts with ten characters for each file. This screenshot shows a regular file (because the first character is a -).

```
gert@ubuntu:~/test$ ls -l proc42.bash
-rwxr-xr--  1 gert proj 984 Feb  6 12:01 proc42.bash
```

Below is a table describing the function of all ten characters.

Table 32.3. Unix file permissions position

position	characters	function
1	-	this is a regular file
2-4	rwx	permissions for the **user owner**
5-7	r-x	permissions for the **group owner**
8-10	r--	permissions for **others**

When you are the **user owner** of a file, then the **user owner permissions** apply to you. The rest of the permissions have no influence on your access to the file.
When you belong to the **group** that is the **group owner** of a file, then the **group owner permissions** apply to you. The rest of the permissions have no influence on your access to the file.
When you are not the **user owner** of a file and you do not belong to the **group owner**, then the **others permissions** apply to you. The rest of the permissions have no influence on your access to the file.

permission examples

Some example combinations on files and directories are seen in this screenshot. The name of the file explains the permissions.

```
gert@ubuntu:~/perms$ ls -lh
total 12K
drwxr-xr-x 2 gert gert 4.0K 2007-02-07 22:26
AllEnter_UserCreateDelete
-rwxrwxrwx 1 gert gert    0 2007-02-07 22:21
EveryoneFullControl.txt
-r--r----- 1 gert gert    0 2007-02-07 22:21 OnlyOwnersRead.txt
-rwxrwx--- 1 gert gert    0 2007-02-07 22:21
OwnersAll_RestNothing.txt
dr-xr-x--- 2 gert gert 4.0K 2007-02-07 22:25 UserAndGroupEnter
dr-x------ 2 gert gert 4.0K 2007-02-07 22:25 OnlyUserEnter
gert@ubuntu:~/perms$
```

To summarise, the first **rwx** triplet represents the permissions for the **user owner**. The second triplet corresponds to the **group owner**; it specifies permissions for all members of that group. The third triplet defines permissions for all **other** users that are not the user owner and are not a member of the group owner.

setting permissions (chmod)

Permissions can be changed with **chmod**. The first example gives the user owner execute permissions.

```
gert@ubuntu:~/perms$ ls -l permissions.txt
-rw-r--r-- 1 gert gert 0 2007-02-07 22:34 permissions.txt
gert@ubuntu:~/perms$ chmod u+x permissions.txt
gert@ubuntu:~/perms$ ls -l permissions.txt
-rwxr--r-- 1 gert gert 0 2007-02-07 22:34 permissions.txt
```

This example removes the group owners read permission.

```
gert@ubuntu:~/perms$ chmod g-r permissions.txt
gert@ubuntu:~/perms$ ls -l permissions.txt
-rwx---r-- 1 gert gert 0 2007-02-07 22:34 permissions.txt
```

This example removes the others read permission.

```
gert@ubuntu:~/perms$ chmod o-r permissions.txt
gert@ubuntu:~/perms$ ls -l permissions.txt
-rwx------ 1 gert gert 0 2007-02-07 22:34 permissions.txt
```

This example gives all of them the write permission.

```
gert@ubuntu:~/perms$ chmod a+w permissions.txt
gert@ubuntu:~/perms$ ls -l permissions.txt
-rwx-w--w- 1 gert gert 0 2007-02-07 22:34 permissions.txt
```

You don't even have to type the a.

```
gert@ubuntu:~/perms$ chmod +x permissions.txt
gert@ubuntu:~/perms$ ls -l permissions.txt
-rwx-wx-wx 1 gert gert 0 2007-02-07 22:34 permissions.txt
```

You can also set explicit permissions.

```
gert@ubuntu:~/perms$ chmod u=rw permissions.txt
gert@ubuntu:~/perms$ ls -l permissions.txt
-rw--wx-wx 1 gert gert 0 2007-02-07 22:34 permissions.txt
```

Feel free to make any kind of combination.

```
gert@ubuntu:~/perms$ chmod u=rw,g=rw,o=r permissions.txt
gert@ubuntu:~/perms$ ls -l permissions.txt
-rw-rw-r-- 1 gert gert 0 2007-02-07 22:34 permissions.txt
```

Even fishy combinations are accepted by chmod.

```
gert@ubuntu:~/perms$ chmod u=rwx,ug+rw,o=r permissions.txt
gert@ubuntu:~/perms$ ls -l permissions.txt
-rwxrw-r-- 1 gert gert 0 2007-02-07 22:34 permissions.txt
```

setting octal permissions

Most Unix administrators will use the **old school** octal system to talk about and set permissions. Look at the triplet bitwise, equating r to 4, w to 2, and x to 1.

Table 32.4. Octal permissions

binary	octal	permission
000	0	---
001	1	--x
010	2	-w-
011	3	-wx
100	4	r--
101	5	r-x
110	6	rw-
111	7	rwx

This makes **777** equal to rwxrwxrwx and by the same logic, 654 mean rw-r-xr-- . The **chmod** command will accept these numbers.

```
gert@ubuntu:~/perms$ chmod 777 permissions.txt
gert@ubuntu:~/perms$ ls -l permissions.txt
-rwxrwxrwx 1 gert gert 0 2007-02-07 22:34 permissions.txt
gert@ubuntu:~/perms$ chmod 664 permissions.txt
gert@ubuntu:~/perms$ ls -l permissions.txt
-rw-rw-r-- 1 gert gert 0 2007-02-07 22:34 permissions.txt
gert@ubuntu:~/perms$ chmod 750 permissions.txt
gert@ubuntu:~/perms$ ls -l permissions.txt
-rwxr-x--- 1 gert gert 0 2007-02-07 22:34 permissions.txt
```

umask

When creating a file or directory, a set of default permissions are applied. These default permissions are determined by the **umask**. The **umask** specifies permissions that you do not want set on by default. You can display the **umask** with the **umask** command.

```
gert@ubuntu:~$ umask
0002
gert@ubuntu:~$ umask -S
u=rwx,g=rwx,o=rx
gert@ubuntu:~$ mkdir testdir
gert@ubuntu:~$ ls -ld testdir
drwxrwxr-x  1 gert gert 0 Jul 24 06:03 testdir
gert@ubuntu:~$ touch testfile
gert@ubuntu:~$ ls -l testfile
-rw-rw-r--  1 gert gert 0 Jul 24 06:03 testfile
gert@ubuntu:~$
```

As you can also see, the file is also not executable by default. This is a general security feature among Unixes; newly created files are never executable by default. You have to explicitly do a **chmod +x** to make a file executable. This also means that the 1 bit in the **umask** has no meaning--a **umask** of 0022 is the same as 0033.

you can change the umask in two ways:

```
gert@ubuntu:~$ umask
0002
gert@ubuntu:~$ umask -S
u=rwx,g=rwx,o=rx
gert@ubuntu:~$ umask 0022
gert@ubuntu:~$ umask
0022
gert@ubuntu:~$ umask -S
u=rwx,g=rx,o=rx
gert@ubuntu:~$ umask u=rwx,g=rwx,o=rx
gert@ubuntu:~$ umask
0002
gert@ubuntu:~$ umask -S
u=rwx,g=rwx,o=rx
```

If you want to keep de new value of the umask you can set the command in ~/.profile or in ~/.bashrc

mkdir -m

When creating directories with **mkdir** you can use the **-m** option to set the **mode**. This screenshot explains.

```
gert@ubuntu:~$ mkdir -m 700 MyDir
gert@ubuntu:~$ mkdir -m 777 Public
gert@ubuntu:~$ ls -dl MyDir/ Public/
drwx------ 2 gert gert 4096 2011-10-16 19:16 MyDir/
drwxrwxrwx 2 gert gert 4096 2011-10-16 19:16 Public/
```

cp -p

To **preserve permissions** and **time stamps** from source files, use **cp -p**.

```
gert@ubuntu:~/perms$ sudo cp file* cp
gert@ubuntu:~/perms$ sudo cp -p file* cpp
gert@ubuntu:~/perms$ ls -l *
-rwx------ 1 gert gert 0 2018-08-25 13:26 file33
-rwxr-x--- 1 gert gert 0 2018-08-25 13:26 file42

cp:
total 0
-rw-r--r-- 1 root root 0 2020-11-14 15:02 file33
-rw-r--r-- 1 root root 0 2020-11-14 15:02 file42

cpp:
total 0
-rwx------ 1 gert gert 0 2018-08-25 13:26 file33
-rwxr-x--- 1 gert gert 0 2018-08-25 13:26 file42
```