

Linux Primer

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Unix and GNU/Linux

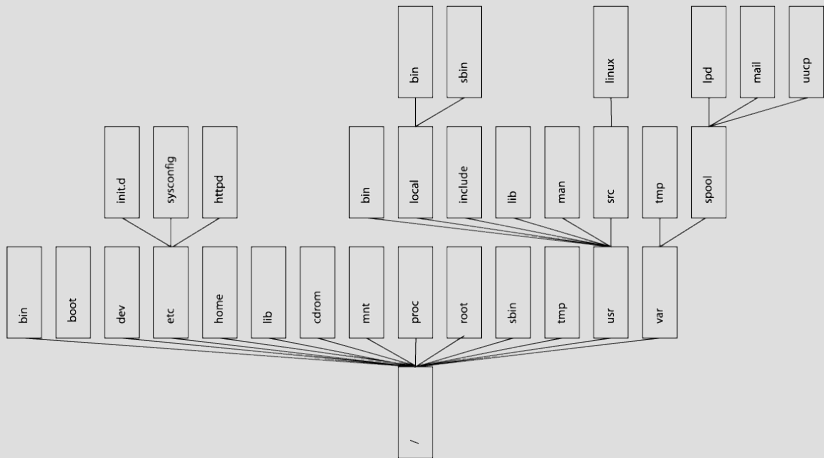
- term Unix (Plural: Unices) is used for all operating systems that are based on the original Unix-Draft (AT&T)
- today influences from Unix can be found in almost all modern operating systems
- it's ideas and concepts can be found everywhere
- GNU/Linux and the free BSD-systems re-implement Unix's behavior and interfaces and add own extensions
- when talking about the operating system in a strict sense one would have to talk about „GNU/Linux“ as this includes the kernel (Linux) as well as the system tools

Literature

- [Linux in a Nutshell](#)
- [Advanced Bash-Scripting Guide](#)
- [LRZ – Hochschulschriften](#)
- [LRZ – Kursprogramm zu Unix und GNU/Linux](#)
- [Google Search](#)
- [Codename: Linux \(2001\)](#)

Properties of GNU/Linux

- GNU/Linux consists of a kernel
 - ▶ only the kernel controls devices and processes
 - ▶ provides system calls as interface for the programs
 - ▶ a variety of programs complete the operating system
- file system is organized hierarchically with arbitrary subdirectories
 - ▶ inverse tree structure
 - ▶ „/“ is the root directory



- a basic principle in GNU/Linux and Unix
 - ▶ „Everything is a file!“
 - ▶ this generalized file concept is inherently included
 - ▶ easy and consistent interface for the different applications
 - ▶ exceptionally easy input/output redirecting into these files
 - ▶ linking of several programs via these pipes
- all Unix-like operating systems have a graphical user interface (X11)
- historically Unix is closely linked to the programming language C

- among the most important properties of GNU/Linux are
 - ▶ high stability
 - ▶ multiuser
 - ▶ multitasking
 - ▶ multithreading
 - ▶ memory protection
 - ▶ virtual memory
 - ▶ TCP/IP network support
 - ▶ fully developed shell
 - ▶ vast variety of programs for almost any task
 - ▶ outstanding scripting possibilities

Using a GNU/Linux system – access

- user account usually consists of user name, password and additional information
- authentication by user name and password
- authorization afterwards, using the additional information
- logging on and off is possible via a graphical user interface or a text shell

Using a GNU/Linux system – user groups

- classification of users enables detailed permission management
- for every user, the GNU/Linux world is divided into three classes
 - ▶ u = login **u**ser
 - ▶ g = **g**roup
 - ▶ o = **o**thers
- all users are identified via a **UID** (**u**ser **i**dentification number), that is directly mapped to the user name
- users have one or more additional **GID** (**g**roup **i**dentification number) to determine the groups he/she is associated with (permission classification together with other members of the group)
- all users that are not part of this group are considered **others**
- for u, g and o, read, write and execute permissions can be set; they are stored as file attributes

Using a GNU/Linux system – command syntax

- apart from very few exceptions a GNU/Linux command has the syntax

```
# COMMAND -OPTION PARAMETER
```

- introduction into the most important commands will be covered in the next chapter
- options influence the execution of a command
 - ▶ short form for options `-a`
 - ▶ long form for options `--all`
- parameters are mostly filenames

Using a GNU/Linux system – documentation

- every system has built-in documentation/help

```
# man COMMAND
```

- each man page is separated into individual subsections
 - ▶ NAME – name of the command
 - ▶ SYNOPSIS – syntax description
 - ▶ DESCRIPTION – detailed description of the command
 - ▶ OPTIONS – list of all options with a short description
 - ▶ COMMANDS – instructions for interactive programs
 - ▶ FILES – files that are associated with the command
 - ▶ SEE ALSO – references to similar commands and manual entries
 - ▶ EXAMPLE – examples for calling the command
 - ▶ BUGS – known bugs and issues
- the commands `info` and `apropos` give additional information

Using a GNU/Linux system – usage of the system

- in today's „window world“ the command line seems complicated
 - ▶ all user tasks can be performed without the command line
 - ▶ higher comfort comes with less driving fun
- GNU/Linux systems are like building sets
 - ▶ a set of programs is available
 - ▶ they can be combined for different tasks
- it's not always necessary to use bloated programs if it is possible to smartly combine the small, specialized programs

- Terminal (Shell)
 - ▶ accepts commands
 - ▶ processes them
 - ▶ starts programs
 - ▶ outputs the result
- input of commands according to the forementioned syntax
 - ▶ the way you input a command is not only determined by the syntax of the command you call, but also by the syntax of the shell used within the terminal
 - ▶ before execution, the command is parsed (set of changes to the input)
 - ▶ these changes have nothing to do with the command that has been called, but are done by the shell applying an always identical set of syntactic rules (many simplifications possible at command input)

Using a GNU/Linux system – files

- from the user's point of view, a file is always a series of logically connected information
- from the system's point of view there is only a finite series of bytes
- in GNU/Linux, there are the following important types of files
 - ▶ regular file \equiv file containing data, text or a program
 - ▶ file folder \equiv file containing references to other files
 - ▶ device file \equiv file containing a reference to a physical device
 - ▶ pipe \equiv file for system internal process communication

- each user has one „HOME directory“

```
# echo $HOME
```

- during his/her session, each user has a „working directory“

```
# echo $PWD
```

- file access always via filenames
- filename can be chosen arbitrarily
 - ▶ with some constraints (name conventions)
- file can be addressed via its absolute or relative path
- one single file can be linked from different places in the directory tree and have different names

- each file has a set of attributes
 - ▶ name of file
 - ▶ path of file
 - ▶ type of file
 - ▶ UID and GID of owner
 - ▶ access permissions
 - ▶ length of file
 - ▶ node number
 - ▶ number of links, references to the file
 - ▶ date of creation, last change and last access
- user can change the attributes
- editing of a set of files by wild cards
 - ▶ ? exactly one arbitrary character
 - ▶ * arbitrarily many characters
 - ▶ [abc] exactly one of the given characters
 - ▶ [a-d] a character from within the given range
 - ▶ [!abc] none of the given characters

What is a shell?

- a program with which the system can understand the users commands
- often called command interpreter (shell interpretes the command)
- successful login always starts the personal login shell
- currently active shell:

```
gkd22aa@cip50:~$ echo $SHELL
```

What kinds of shells are there?

- simple shells:
 - ▶ Bourne-Shell (`sh`)
 - ▶ Korn-Shell (`ksh`)
 - ▶ C-Shell (`csh`)
- extended shells:
 - ▶ Bourne-Again-Shell (`bash`)
 - ▶ T-C-Shell (`tcsh`)
 - ▶ Z-Shell (`zsh`)

How can I switch between the different shells?

```
gkd22aa@cip50:~$ echo $SHELL
/bin/bash
gkd22aa@cip50:~$ tcsh
cip50:~>
cip50:~> exit
gkd22aa@cip50:~$ ksh
$
$ exit
```

What is the prompt?

- prompt to enter a command
- depending on the shell the appearance of the prompt can be different
- changing the prompt using the variable PS1

```
gkd22aa@cip50:~$ ls
Desktop  maildir
gkd22aa@cip50:~$ echo $PS1
${debian_chroot:+($debian_chroot)}\u@\h:\w\$
gkd22aa@cip50:~$ PS1="abc123# "
abc123# ls
Desktop  maildir
abc123#
```

What is a variable?

- in the most general sense simply a container for values
- a variable
 - ▶ is addressed by a designated name
 - ▶ has a certain location in the memory
 - ▶ its value can change
- in the shells there is only one type of variables
- variables can be created and changed arbitrarily
- environment variables
 - ▶ are initialized at login
 - ▶ influence the behavior of the shell
 - ▶ influence the commands

Which environment variables have been initialized/set?

```
gkd22aa@cip50:~$ env
TERM=xterm
SHELL=/bin/bash
USER=gkd22aa
LOGNAME=gkd22aa
HOME=/home/cip/gkd22aa
PWD=/home/cip/gkd22aa
LANG=en_GB.UTF-8
MAIL=/var/mail/gkd22aa
PATH=/usr/local/bin:/usr/bin:/bin:/usr/games
DISPLAY=localhost:10.0
```

What types of programs are there?

- as you know, programs are started from the shell
- there are two different groups of programs
 - ▶ programs that are stored on the hard disk
 - ▶ programs that are „programmed“ into the shell (shell builtin programs)
- to obtain details about the type

```
gkd22aa@cip50:~$ type mkdir
mkdir is /bin/mkdir
gkd22aa@cip50:~$ type echo
echo is a shell builtin
gkd22aa@cip50:~$ type ls
ls is aliased to 'ls --color=auto'
```

- obtaining the path of a command

```
gkd22aa@cip50:~$ which echo
/bin/echo
gkd22aa@cip50:~$ which gnuplot
/usr/bin/gnuplot
```

- just entering echo → shell builtin variant
- entering /bin/echo → program from respective path
- there might be a slightly different functionality depending on the variant

How do you string commands together?

Imagine you want to start five commands after each other, but each of them will take a certain, undetermined amount of time. Possibly you will have to wait in front of the computer for hours and wait until each of the commands is finished in order to start the next one.

- the shell can execute more than one instruction per command
- a command doesn't end before the return key is pressed
- instructions can be separated by semicolons

```
gkd22aa@cip50:~$ echo $HOME; ls Desktop; date -R  
/home/cip/gkd22aa  
LinuxCourse.pdf  Home.desktop  System.desktop  
Sun, 01 Nov 2009 16:00:42 +0100
```

- continue only when successful

```
gkd22aa@cip50:~$ dtae -R && ls $HOME  
-bash: dtae: command not found
```

- continue only when unsuccessful

```
gkd22aa@cip50:~$ dtae -R || echo "Help, an error."  
-bash: dtae: command not found  
Help, an error.
```

Multi-Line-Commands

- often commands stretch over multiple lines
- current line can be continued in the next line with the backslash operator (\)

```
gkd22aa@cip50:~$ find /usr/share/WindowMaker/ \  
> -type f -name BlueImage.jpeg  
/usr/share/WindowMaker/Backgrounds/BlueImage.jpeg  
gkd22aa@cip50:~$ find /usr/share/WindowMaker/ \  
> -type f \  
> -name \  
> BlueImage.jpeg  
/usr/share/WindowMaker/Backgrounds/BlueImage.jpeg
```

Working with directories – paths

- the general form of a filename or of a directory name, specifies a unique location in a file system
- points to a file system location by following the directory tree hierarchy expressed in a string of characters in which path components, separated by a the slash /, represent each directory
- GNU/Linux distinguishes between two kinds of paths:
 - ▶ absolute path
 - ▶ points to the same location on one file system regardless of the working directory or combined paths
 - ▶ usually written in reference to a root directory
 - ▶ absolute path always starts with a slash /
 - ▶ relative path
 - ▶ a path relative to the working directory of the user or application, so the absolute path will not have to be given
 - ▶ always starts with a subdirectory or ../

- working directory

```
gkd22aa@cip50:~$ echo $PWD  
/home/cip/gkd22aa  
gkd22aa@cip50:~$ pwd  
/home/cip/gkd22aa
```

Change directory

```
cd [PATH]
```

- [PATH]
 - ▶ replaced with absolute or relative path

The following characters have a special meaning for the shell:

- `.`
 - ▶ points to the working directory
- `..`
 - ▶ points to the directory one level above the working directory
- `-`
 - ▶ points to the last working directory
- `~`
 - ▶ points to your home directory
- `$HOME`
 - ▶ points to your home directory

```
gkd22aa@cip50:~$ cd ..
gkd22aa@cip50:/home/cip$ cd ..
gkd22aa@cip50:/home$ pwd
/home
gkd22aa@cip50:/home$ cd ../usr/bin
gkd22aa@cip50:/usr/bin$ pwd
/usr/bin
gkd22aa@cip50:/usr/bin$ cd ~
gkd22aa@cip50:~$ cd /usr/bin
gkd22aa@cip50:/usr/bin$ pwd
/usr/bin
gkd22aa@cip50:/usr/bin$ cd $HOME/Desktop
gkd22aa@cip50:~/Desktop$ pwd
/home/cip/gkd22aa/Desktop
```


List directory contents

```
ls [OPTION] [PATH]
```

- [PATH]
 - ▶ replaced with absolute or relative path
- [OPTION]
 - ▶ -a
 - ▶ do not ignore entries starting with . (hidden files/directories)
 - ▶ -l
 - ▶ use a long listing format
 - ▶ -r
 - ▶ reverse order while sorting
 - ▶ -t
 - ▶ sort by modification time

```
gkd22aa@cip50:~$ ls Desktop
LinuxCourse.pdf  Home.desktop
gkd22aa@cip50:~$ ls -a
.                .Xauthority     .bash_logout    .dmrc
..               .kderc          .mcp             Desktop
gkd22aa@cip50:~$ ls -l
drwx-----  2 gkd22aa gkd22 4096 Oct 26 08:37 Desktop
drwx-----  2 gkd22aa gkd22 4096 Oct 19 11:50 maildir
gkd22aa@cip50:~$ ls -al
drwxr-xr-x   15 gkd22aa gkd22 4096 Nov  2 08:04 .
drwxr-xr-x 1759 root     root 32768 Oct 29 16:26 ..
-rw-----   1 gkd22aa gkd22   51 Nov  2 08:04 .Xauthority
drwx-----   3 gkd22aa gkd22 4096 Oct 26 08:36 .adobe
```

```
gkd22aa@cip50:~$ ls /
adm boot  chkpnt dev  etc    lib    mnt    opt    sbin sys  usr
bin cdrom data  home initrd media proc root srv  tmp var
gkd22aa@cip50:~$ ls /usr/
X11R6 bin games include lib lib64 local man sbin share src
gkd22aa@cip50:~$ ls /usr/share/texmf-texlive/
bibtex doc ls-R makeindex tex
gkd22aa@cip50:~$ ls -l /usr/share/texmf-texlive/
drwxr-xr-x 4 root root 4096 Feb 25 2008 bibtex
lrwxrwxrwx 1 root root   18 Feb 25 2008 doc -> ../doc/texlive-do
lrwxrwxrwx 1 root root   27 Feb 25 2008 ls-R -> /var/lib/texmf/l
drwxr-xr-x 4 root root 4096 Feb 25 2008 makeindex
drwxr-xr-x 4 root root 4096 Feb 25 2008 tex
```

```
gkd22aa@cip50:~$ touch fileB && sleep 30 && touch fileA \  
&& sleep 30 && touch fileC  
gkd22aa@cip50:~$ ls -l file?  
-rw----- 1 gkd22aa gkd22 0 Feb 16 16:30 fileA  
-rw----- 1 gkd22aa gkd22 0 Feb 16 16:29 fileB  
-rw----- 1 gkd22aa gkd22 0 Feb 16 16:30 fileC  
gkd22aa@cip50:~$ ls -lt file?  
-rw----- 1 gkd22aa gkd22 0 Feb 16 16:30 fileC  
-rw----- 1 gkd22aa gkd22 0 Feb 16 16:30 fileA  
-rw----- 1 gkd22aa gkd22 0 Feb 16 16:29 fileB  
gkd22aa@cip50:~$ ls -ltr file?  
-rw----- 1 gkd22aa gkd22 0 Feb 16 16:29 fileB  
-rw----- 1 gkd22aa gkd22 0 Feb 16 16:30 fileA  
-rw----- 1 gkd22aa gkd22 0 Feb 16 16:30 fileC
```

- Is it a absolute or relative path?
- To which location does it point to?

```
bin/checkLocations.sh
```

```
../../../../sys/kernel/
```

```
/usr/share/gmt/../../../../lib/ruby/1.8/../../../../local/bin/
```

```
/../../../../etc/default
```

Some basic commands

```
echo [TEXT]
```

- [TEXT]
 - ▶ output is written to terminal
 - ▶ please put "..." around

```
gkd22aa@cip50:~$ echo " text output from $USER "  
text output from gkd22aa
```

```
sleep [SECONDS]
```

- [SECONDS]
 - ▶ shell sleeps for the specified numbers of seconds

```
gkd22aa@cip50:~$ date ; sleep 30 ; date
Fri Nov  6 13:43:51 CET 2009
Fri Nov  6 13:44:21 CET 2009
gkd22aa@cip50:~$
```

```
cat [FILE]  
tac [FILE]
```

- [FILE]
 - ▶ concatenate files and print on the standard output
 - ▶ concatenate files and print on the standard output in reverse order

```
gkd22aa@cip50:~$ cat /etc/ntp.conf .dmrc  
logfile /var/log/ntpd  
driftfile /var/lib/ntp/ntp.drift  
#broadcastclient yes  
server 129.187.254.32  
server 10.156.8.31  
[Desktop]  
Session=default
```


Make directories

```
mkdir [PATH]
```

- [PATH]
 - ▶ replaced with absolute or relative path

```
gkd22aa@cip50:~$ ls
Desktop
gkd22aa@cip50:~$ mkdir dirA ; ls
Desktop  dirA
gkd22aa@cip50:~$ mkdir $HOME/dirB
gkd22aa@cip50:~$ mkdir /home/cip/$USER/dirC
gkd22aa@cip50:~$ ls
Desktop  dirA  dirB  dirC
```

Remove empty directories

```
rmmdir [PATH]
```

- [PATH]
 - ▶ replaced with absolute or relative path
 - ▶ directories must be empty

```
gkd22aa@cip50:~$ ls
Desktop  dirA  dirB  dirC
gkd22aa@cip50:~$ rmmdir dirA dir[BC]
gkd22aa@cip50:~$ ls
Desktop
gkd22aa@cip50:~$ rmmdir Desktop/
rmmdir: Desktop/: Directory not empty
```

Copy files and directories

```
cp [OPTION] SOURCE DEST
```

- [OPTION]
 - ▶ -a
 - ▶ preserve all file/directory attributes
 - ▶ -b
 - ▶ make a backup of each existing destination file
 - ▶ -i
 - ▶ prompt before overwrite
 - ▶ -r
 - ▶ copy directories recursively
 - ▶ -u
 - ▶ copy only when the SOURCE file is newer than the destination file or when the destination file is missing

- SOURCE DEST

- ▶ replaced with
 - ▶ filename or
 - ▶ absolute or
 - ▶ relative path

```
gkd22aa@cip50:~$ cp .bashrc newFile
gkd22aa@cip50:~$ ls
Desktop  maildir  newFile
gkd22aa@cip50:~$ mkdir TEST
gkd22aa@cip50:~$ cp /etc/profile \
  /usr/share/doc/bash/README.abs-guide TEST/
gkd22aa@cip50:~$ ls -l TEST/
-rw----- 1 gkd22aa gkd22 1105 Nov  8 15:33 README.abs-guide
-rw----- 1 gkd22aa gkd22  486 Nov  8 15:33 profile
```

```
gkd22aa@cip50:~$ cp -i /etc/profile \
  /usr/share/doc/bash/README.abs-guide TEST/
cp: overwrite 'TEST/profile'? y
cp: overwrite 'TEST/README.abs-guide'? y
gkd22aa@cip50:~$ ls -l TEST/
-rw----- 1 gkd22aa gkd22 1105 Nov  8 15:34 README.abs-guide
-rw----- 1 gkd22aa gkd22  486 Nov  8 15:34 profile
gkd22aa@cip50:~$ cp -b /etc/profile \
  /usr/share/doc/bash/README.abs-guide TEST/
cp: overwrite 'TEST/profile'? y
cp: overwrite 'TEST/README.abs-guide'? y
gkd22aa@cip50:~$ ls -l TEST/
-rw----- 1 gkd22aa gkd22 1105 Nov  8 15:36 README.abs-guide
-rw----- 1 gkd22aa gkd22 1105 Nov  8 15:34 README.abs-guide~
-rw----- 1 gkd22aa gkd22  486 Nov  8 15:36 profile
-rw----- 1 gkd22aa gkd22  486 Nov  8 15:34 profile~
```

```
gkd22aa@cip50:~$ cp -r TEST test
gkd22aa@cip50:~$ ls
Desktop  TEST  maildir  test
gkd22aa@cip50:~$ ls -l TEST test
TEST/:
-rw----- 1 gkd22aa gkd22 1105 Nov  8 15:37 README.abs-guide
-rw----- 1 gkd22aa gkd22 1105 Nov  8 15:36 README.abs-guide~
-rw----- 1 gkd22aa gkd22  486 Nov  8 15:37 profile
-rw----- 1 gkd22aa gkd22  486 Nov  8 15:36 profile~

test/:
-rw----- 1 gkd22aa gkd22 1105 Nov  8 15:38 README.abs-guide
-rw----- 1 gkd22aa gkd22 1105 Nov  8 15:38 README.abs-guide~
-rw----- 1 gkd22aa gkd22  486 Nov  8 15:38 profile
-rw----- 1 gkd22aa gkd22  486 Nov  8 15:38 profile~
```

Move or rename files or directories

```
mv [OPTION] SOURCE DEST
```

- [OPTION]
 - ▶ -b
 - ▶ make a backup of each existing destination file
 - ▶ -i
 - ▶ prompt before overwrite
 - ▶ -u
 - ▶ move only when the SOURCE file is newer than the destination file or when the destination file is missing
- SOURCE DEST
 - ▶ replaced with
 - ▶ filename or
 - ▶ absolute or
 - ▶ relative path

```
gkd22aa@cip50:~$ cd test/  
gkd22aa@cip50:~/test$ ls  
README.abs-guide  README.abs-guide~  profile  profile~  
gkd22aa@cip50:~/test$ mv profile Data-1.txt  
gkd22aa@cip50:~/test$ ls  
Data-1.txt  README.abs-guide  README.abs-guide~  profile~  
gkd22aa@cip50:~/test$ cd ..  
gkd22aa@cip50:~$ mv test/ try  
gkd22aa@cip50:~$ ls  
Desktop  TEST  maildir  try  
gkd22aa@cip50:~$ mv TEST/ try/  
gkd22aa@cip50:~$ ls try/  
Data-1.txt  README.abs-guide  README.abs-guide~  TEST  profile~
```


Remove files or directories

```
rm [OPTION] FILE
```

- [OPTION]
 - ▶ -i
 - ▶ prompt before every removal
 - ▶ -r
 - ▶ remove directories and their contents recursively
 - ▶ -f
 - ▶ ignore nonexistent files, never prompt!
- FILE
 - ▶ replaced with
 - ▶ filename or
 - ▶ absolute or
 - ▶ relative path

```
gkd22aa@cip50:~$ rm try/Data-1.txt
rm: remove regular file 'try/Data-1.txt'? y
gkd22aa@cip50:~$ ls try/
README.abs-guide  README.abs-guide~  TEST  profile~
gkd22aa@cip50:~$ rm -r try/TEST/
rm: descend into directory 'try/TEST/'? y
rm: remove regular file 'try/TEST/profile'? y
rm: remove regular file 'try/TEST/README.abs-guide~'? y
rm: remove regular file 'try/TEST/profile~'? y
rm: remove regular file 'try/TEST/README.abs-guide'? y
rm: remove directory 'try/TEST/'? y
gkd22aa@cip50:~$ ls try/
README.abs-guide  README.abs-guide~  profile~
gkd22aa@cip50:~$ rm -rf try/
gkd22aa@cip50:~$ ls
Desktop  maildir
```

Make links between files

```
ln [OPTION] SOURCE LINK_NAME
```

- [OPTION]

- ▶ -s

- ▶ make symbolic links instead of hard links

```
gkd22aa@cip50:~$ ln -s maildir/ E-MAIL
gkd22aa@cip50:~$ ln -s /etc/profile $HOME/
gkd22aa@cip50:~$ ls -l && rm -f E-MAIL profile
drwx----- 2 gkd22aa gkd22 4096 Nov  8 15:27 Desktop
lrwxrwxrwx 1 gkd22aa gkd22    8 Nov  8 16:14 E-MAIL -> maildir/
drwx----- 2 gkd22aa gkd22 4096 Oct 19 11:50 maildir
lrwxrwxrwx 1 gkd22aa gkd22   12 Nov  8 16:14 profile -> /etc/prof
```

Commands for files and directories

```
touch FILE
```

- change file timestamps or create empty file

```
gkd22aa@cip50:~$ ls -l .bashrc ; echo "###" ; \  
sleep 80 ; echo "###" ; \  
touch .bashrc ; ls -l .bashrc  
-rw----- 1 gkd22aa gkd22 2278 Nov  8 16:22 .bashrc  
###  
###  
-rw----- 1 gkd22aa gkd22 2278 Nov  8 16:24 .bashrc
```

`wc [OPTION] FILE`

- print newline, word, and byte counts for each file
- `[OPTION]`
 - ▶ `-C`
 - ▶ print the byte counts
 - ▶ `-w`
 - ▶ print the word counts
 - ▶ `-l`
 - ▶ print the newline counts

```
gkd22aa@cip50:~$ wc /etc/hosts
```

```
3 9 104 /etc/hosts
```

```
gkd22aa@cip50:~$ cat /etc/host* /etc/profile | wc -l
```

```
64
```

less [OPTION] FILE

- file viewer
- [OPTION]
 - ▶ -N
 - ▶ causes a line number to be displayed at the beginning of each line in the display
 - ▶ -E
 - ▶ causes less to automatically exit the first time it reaches end-of-file
- Navigation
 - ▶ to move in less – arrow keys
 - ▶ to quit less – q
 - ▶ to search in less – /[PATTERN]

```
gkd22aa@cip50:~$ less -N /etc/bash.bashrc
 1 # System-wide .bashrc file for interactive bash(1) shells.
 2
 3 # To enable the settings / commands in this file for login
 4 # this file has to be sourced in /etc/profile.
 5
...
gkd22aa@cip50:~$ cat /etc/default/* | less
# Specify options for acpid startup, Debian default is to enable
# use of sockets at a non-default position
OPTIONS=s /var/run/acpid.socket"

# Specify modules to load on acpid's startup
# MODULES may be uncommented to load "none", contain the string
# to load all acpi related modules or simply a space separated
...
```

```
head [OPTION] [FILE]  
tail [OPTION] [FILE]
```

- output the first part or last part of files
- [OPTION]
 - ▶ -n i
 - ▶ print the first or last i lines instead of the first or last 10
 - ▶ -f
 - ▶ only appropriate for tail
 - ▶ command leaves [FILE] opened
 - ▶ output appended data as the file grows
 - ▶ to quit – STRG-C


```
gkd22aa@cip50:~$ head -n 7 /etc/profile
# /etc/profile: system-wide .profile file for the Bourne shell
# and Bourne compatible shells (bash(1), ksh(1), ash(1), ...).

if [ „id -u“ -eq 0 ]; then
    PATH="/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/
else
    PATH="/usr/local/bin:/usr/bin:/bin:/usr/games"
gkd22aa@cip50:~$ tail -n 4 -f /var/log/mail.log
Nov 13 04:11:24 cip50 postfix/cleanup[7544]: BEE3574477: message-
Nov 13 04:11:24 cip50 postfix/qmgr[3158]: BEE3574477: from=<root@
Nov 13 04:11:24 cip50 postfix/smtp[7550]: BEE3574477: to=<spann@c
Nov 13 04:11:24 cip50 postfix/qmgr[3158]: BEE3574477: removed
...
gkd22aa@cip50:~$ head -n 1 tomo.0??[05].dat
...
```

```
sort [OPTION] [FILE]
```

- sort lines of text files
- [OPTION]
 - ▶ -n
 - ▶ compare according to string numerical value
 - ▶ -u
 - ▶ output only the first of an equal run

```
gkd22aa@cip50:~$ sort /etc/hosts
10.153.84.129 libby.cipmath.loc libby cip04
10.153.84.179 cip50.cipmath.loc cip50
127.0.0.1 localhost
```

```
gkd22aa@cip50:~$ wget \
  http://www.geophysik.uni-muenchen.de/~oeser/LV/Shell/sort_ex.txt
gkd22aa@cip50:~$ cat sort_ex.txt
...
gkd22aa@cip50:~$ sort sort_ex.txt
...
gkd22aa@cip50:~$ sort -u sort_ex.txt
000 IP
001 ICMP
002 IGMP
003 GGP
006 TCP
012 PUP
017 UDP
022 IDP
...
```

Search for files in a directory hierarchy

```
find [OPTION] [PATH] [TEST] [ACTION]
```

- [OPTION]
 - ▶ -P
 - ▶ never follow symbolic links
 - ▶ -L
 - ▶ follow symbolic links
- [PATH]
 - ▶ replaced with
 - ▶ absolute or
 - ▶ relative path
- [TEST]
 - ▶ -amin/atime [n]
 - ▶ file was last accessed [n]*24 hours ago

- [TEST]
 - ▶ -cmin/ctime [n]
 - ▶ file's status was last changed [n]*24 hours ago
 - ▶ -empty
 - ▶ file is empty and is either a regular file or a directory
 - ▶ -gid [n]
 - ▶ file's numeric group ID is [n]
 - ▶ -group [NAME]
 - ▶ file belongs to group gname [NAME]
 - ▶ -mmin/mtime [n]
 - ▶ file's data was last modified [n]*24 hours ago
 - ▶ -name [NAME]
 - ▶ base of file name (the path with the leading directories removed)
matches shell pattern [NAME]
 - ▶ -perm [MODE]
 - ▶ any of the permission bits [MODE] are set for the file

- [TEST]
 - ▶ `-size [n] [cwbkMG]`
 - ▶ file uses `n` units of space (`2k` \equiv 2 Kilobyte)
 - ▶ `-type [TYPE]`
 - ▶ file is of type [TYPE] (b (block special), c (character special), d (directory), p (named pipe (FIFO)), f (regular file), l (symbolic link) and s (socket))
 - ▶ `-uid [UID]`
 - ▶ file's numeric user ID is UID
 - ▶ `-user [NAME]`
 - ▶ file is owned by user [NAME]
 - ▶ `! [TEST]`
 - ▶ true if [TEST] is false
 - ▶ `[TEST] -a / -o [TEST]`
 - ▶ logical AND or logical OR

- [ACTION]
 - ▶ `-exec [CMD] {} \;`
 - ▶ runs the specified command [CMD] on the selected files {} \;
 - ▶ `-print`
 - ▶ print the full file name on the standard output, followed by a newline
 - ▶ `-print0`
 - ▶ print the full file name on the standard output, followed by a null character '\0' instead of the newline character
 - ▶ `-ls`
 - ▶ list current file in `ls -dils` format on standard output
 - ▶ `-fls/fprint [FILE]`
 - ▶ like `-ls` or `-print` but write to [FILE]

```
gkd22aa@cip50:~$ find ~ -name "*.pdf"  
/home/cip/gkd22aa/Desktop/LinuxCourse.pdf
```

```
gkd22aa@cip50:~$ find /usr/ -type d -name examples
/usr/share/apps/kwordquiz/examples
/usr/share/apps/kvotrain/examples
/usr/share/apps/kturtle/examples
/usr/share/apps/artsbuilder/examples
...
gkd22aa@cip50:~$ find /usr/ -type d -name examples -ls
1329753 4 drwxr-xr-x 2 root root 4096 Oct 10 2007 /usr/share/apps
1318914 4 drwxr-xr-x 2 root root 4096 Oct 10 2007 /usr/share/apps
1318710 4 drwxr-xr-x 4 root root 4096 Oct 10 2007 /usr/share/apps
1249525 4 drwxr-xr-x 3 root root 4096 Oct 10 2007 /usr/share/apps
...
gkd22aa@cip50:~$ cp /etc/profile . ; cp -b /etc/profile .
gkd22aa@cip50:~$ find . -name "*~" -print -exec rm -f {} \;
./profile~
```


Print lines matching a pattern

```
grep [OPTION] [PATTERN] [FILE]
```

- [OPTION]
 - ▶ -C
 - ▶ suppress normal output; instead print a count of matching lines for each input file
 - ▶ -v
 - ▶ invert the sense of matching
 - ▶ -H
 - ▶ print the file name for each match
- [PATTERN]
 - ▶ replaced with regular expression
- [FILE]
 - ▶ replaced with filename

```
gkd22aa@cip50:~$ wget \
  http://www.geophysik.uni-muenchen.de/~oeser/LV/Shell/ort_ex.txt \
  http://www.geophysik.uni-muenchen.de/~oeser/LV/Shell/ex-1.xyz \
  http://www.geophysik.uni-muenchen.de/~oeser/LV/Shell/ex-2.xyz
gkd22aa@cip50:~$ less -e *ex*
gkd22aa@cip50:~$ grep a ort_ex.txt
Friedrichshafen
Halle
Furtwangen
...
gkd22aa@cip50:~$ grep -i "[fn]$" *ex*
ex-1.xyz:# Hainichen
ex-2.xyz:# Hainichen
ort_ex.txt:Bremen
ort_ex.txt:Friedrichshafen
...
```

Change file owner and group

```
chown [OPTION] [USER] [FILE]  
chgrp [OPTION] [GROUP] [FILE]
```

- [OPTION]
 - ▶ -R
 - ▶ operate on files and directories recursively
- [FILE]
 - ▶ replaced with
 - ▶ filename or
 - ▶ absolute or
 - ▶ relative path

```
gkd22aa@cip50:~$ finger $USER
Login: gkd22aa           Name: Seminar-Geophys
Directory: /home/cip/gkd22aa      Shell: /bin/bash
On since Fri Feb 17 10:13 (CET) on pts/0 from munich.geophysik
No mail.
No Plan.

gkd22aa@cip50:~$ id
uid=24101(gkd22aa) gid=24100(gkd22) groups=24100(gkd22),117(fuse)
gkd22aa@cip50:~$ chown gkd22aa sort_ex.txt
gkd22aa@cip50:~$ chgrp -R gkd22 Desktop/
gkd22aa@cip50:~$ ls -l Desktop/
total 1240
-rw----- 1 gkd22aa gkd22 1242345 Nov 23 08:31 Datenverarbeitung
-rw----- 1 gkd22aa gkd22    4485 Oct 26 08:28 Home.desktop
-rw----- 1 gkd22aa gkd22    3819 Oct 26 08:28 System.desktop
-rw----- 1 gkd22aa gkd22    5066 Oct 26 08:28 trash.desktop
```

Change file mode bits

```
chmod [OPTION] [MODE] [FILE]
```

- [OPTION]
 - ▶ -R
 - ▶ operate on files and directories recursively
- [MODE]
 - ▶ symbolic notation is the most common method for representing permissions
 - ▶ octal notation is another common method for representing permissions
- [FILE]
 - ▶ replaced with
 - ▶ filename or
 - ▶ absolute or
 - ▶ relative path

```
gkd22aa@cip50:~$ ls -l ex*  
-rw----- 1 gkd22aa gkd22 565 Nov 29 10:17 ex-1.xyz  
-rw----- 1 gkd22aa gkd22 797 Nov 29 10:17 ex-2.xyz
```

- [MODE] – symbolic notation
 - ▶ character 1 is the type of file
 - ▶ next three indicate read, write, and execute permission for each of the three user types
 - ▶ since there are three types of permission for three user classes, there are a total of nine permission bits (three triads)
 - ▶ characters 2 - 4 show owner permissions (u – user)
 - ▶ characters 5 - 7 show group permissions (g – group)
 - ▶ characters 8 - 10 show permissions for all other users (o – others)

```
gkd22aa@cip50:~$ ls -l ex*  
-rw----- 1 gkd22aa gkd22 565 Nov 29 10:17 ex-1.xyz  
-rw----- 1 gkd22aa gkd22 797 Nov 29 10:17 ex-2.xyz
```

- [MODE] – symbolic notation
 - ▶ if there is a "r,w,x" in a particular location (characters 2 - 10), there is permission
 - ▶ if there is a "-" in a particular location (characters 2 - 10), there is no permission
 - ▶ characters 2, 5, 8 indicate read permission (r – read)
 - ▶ characters 3, 6, 9 indicate write permission (w – write)
 - ▶ characters 4, 7, 10 indicate execute permission (x – execute)

```
gkd22aa@cip50:~$ stat -c '%n %a %A' ex*
ex-1.xyz 600 -rw-----
ex-2.xyz 600 -rw-----
```

- [MODE] – octal notation
 - ▶ these permissions are specified in octal
 - ▶ first character is for user, second for group and third is for others
 - ▶ each of these digits is the sum of its component bits; as a result, specific bits add to the sum as it is represented by a numeral:
 - ▶ high bit (4 in binary 100) is for read permission
 - ▶ middle bit (2 in binary 010) is for write permission
 - ▶ low bit (1 in binary 001) is for execute permission
 - ▶ these values never produce ambiguous combinations; each sum represents a specific set of permissions

octal	0	1	2	3	4	5	6	7
binary	000	001	010	011	100	101	110	111

- [MODE] – symbolic and octal notation
 - ▶ execute permission is required to change into a directory

octal	symbolic	interpretation
777	rxwxrwx	full permissions for all
664	rw-rw-r--	read and write permissions for u,g read permission for o
440	r--r-----	read permission for u,g no permission for o

- thus we have to ways to change permissions

```
gkd22aa@cip50:~$ ls -l FILE
-r--r--r-- 1 gkd22aa gkd22 90 Nov 13 15:07 FILE
gkd22aa@cip50:~$ chmod u=rw,g+w,o-r FILE
gkd22aa@cip50:~$ chmod 660 FILE
```

```
gkd22aa@cip50:~$ chmod 755 Desktop/
gkd22aa@cip50:~$ ls -l
drwxr-xr-x 2 gkd22aa gkd22 4096 Nov  8 15:27 Desktop
gkd22aa@cip50:~$ chmod u=rw,g=r,o= *ex*
gkd22aa@cip50:~$ ls -l *ex*
-rw-r----- 1 gkd22aa gkd22 565 Nov 29 10:17 ex-1.xyz
-rw-r----- 1 gkd22aa gkd22 797 Nov 29 10:17 ex-2.xyz
-rw-r----- 1 gkd22aa gkd22 119 Nov 23 07:55 ort_ex.txt
-rw-r----- 1 gkd22aa gkd22  90 Nov 13 15:07 sort_ex.txt
```

Archiving utilities

```
tar [OPTION] [FILE]
```

- [OPTION]
 - ▶ -C
 - ▶ create a new archive
 - ▶ -X
 - ▶ extract files from an archive
 - ▶ -t
 - ▶ list the contents of an archive
 - ▶ -f FILE
 - ▶ use archive FILE
 - ▶ -Z
 - ▶ use gzip compression
 - ▶ -j
 - ▶ use bzip2 compression

- [FILE]
 - ▶ replaced with
 - ▶ filename or
 - ▶ absolute or
 - ▶ relative path

```
gkd22aa@cip50:~$ tar -c -f Example-1.tar -- *ex*
gkd22aa@cip50:~$ ls -l Example-1.tar
-rw----- 1 gkd22aa gkd22 10240 Nov 29 11:58 Example-1.tar
gkd22aa@cip50:~$ tar -t -f Example-1.tar
ex-1.xyz
ex-2.xyz
ort_ex.txt
sort_ex.txt
gkd22aa@cip50:~$ tar -c -f Example-2.tar.gz -z -- *ex*
gkd22aa@cip50:~$ ls -l Example-2.tar.gz
-rw----- 1 gkd22aa gkd22 872 Nov 29 11:59 Example-2.tar.gz
```

Compress or expand files

```
gzip [FILE]  
gunzip [FILE]
```

```
bzip2 [FILE]  
bunzip2 [FILE]
```

```
zip ZIPFILE [FILE]  
unzip ZIPFILE
```

- [FILE]
 - ▶ replaced with
 - ▶ filename or
 - ▶ absolute or
 - ▶ relative path

```
gkd22aa@cip50:~$ bzip2 Example-1.tar
gkd22aa@cip50:~$ ls -l Example-1.tar.bz2
-rw----- 1 gkd22aa gkd22 841 Nov 29 11:58 Example-1.tar.bz2
gkd22aa@cip50:~$ bunzip2 Example-1.tar.bz2
gkd22aa@cip50:~$ gzip *.txt
gkd22aa@cip50:~$ ls -l *.gz
...
gkd22aa@cip50:~$ gunzip *.txt.gz
gkd22aa@cip50:~$ zip xyz.zip ex-*
  adding: ex-1.xyz (deflated 58%)
  adding: ex-2.xyz (deflated 60%)
gkd22aa@cip50:~$ unzip xyz.zip
replace ex-1.xyz? [y]es, [n]o, [A]ll, [N]one, [r]ename: y
  inflating: ex-1.xyz
replace ex-2.xyz? [y]es, [n]o, [A]ll, [N]one, [r]ename: y
  inflating: ex-2.xyz
```

Print files

```
lp [FILE]  
a2ps [FILE]
```

- [FILE]
 - ▶ replaced with
 - ▶ filename or
 - ▶ absolute or
 - ▶ relative path

```
gkd22aa@cip50:~$ a2ps ort_ex.txt  
gkd22aa@cip50:~$ cp /usr/share/tcltk/tk8.5/images/logo.eps .  
gkd22aa@cip50:~$ gv logo.eps  
gkd22aa@cip50:~$ lp logo.eps
```

Print handling

```
lpstat  
cancel  
lpoptions
```

- `lpstat`
 - ▶ print cups status information
- `cancel`
 - ▶ cancel print jobs
- `lpoptions`
 - ▶ display or set printer options and defaults

Additional commands

- `logout` and `exit`
 - ▶ cause the shell to exit
- `passwd`
 - ▶ change user password
- `id`
 - ▶ print real and effective user and group IDs
- `quota -sm`
 - ▶ display disk usage and limits
- `who` and `w`
 - ▶ show who is logged on
- `finger [USERNAME]`
 - ▶ user information lookup program
- `last`
 - ▶ show listing of last logged in users

Process und resource management

top

- display Linux tasks
- keyboard short cuts
 - ▶ h – help
 - ▶ q – quit
 - ▶ u – show processes of specific user
 - ▶ k – kill process with PID

```
top - 14:36:39 up 22:53,  2 users,  load average: 1.00, 1.05, 1.03
Tasks: 113 total,   2 running, 111 sleeping,   0 stopped,   0 zombie
Cpu(s):  0.0%us,  0.0%sy, 50.1%ni, 49.9%id,  0.0%wa,  0.0%hi,  0.0%si,  0.0%st
Mem:   3107484k total, 2735880k used,   371604k free,   217456k buffers
Swap:  2104472k total,    0k used,  2104472k free,   352780k cached
```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
9892	md73ak	30	10	1991m	1.9g	344	R	100	65.6	2:22.35	ldms
1	root	20	0	1940	636	540	S	0	0.0	0:01.28	init

```
ps [OPTION]
```

- report a snapshot of the current processes
- [OPTION]
 - ▶ -e -A
 - ▶ select all processes
 - ▶ -f
 - ▶ does full format listing
 - ▶ -l
 - ▶ does long format listing
 - ▶ -p [PID]
 - ▶ selects the processes whose process ID numbers appear in PID
 - ▶ -u [USERNAME]
 - ▶ selects the processes whose real user name or ID is in the USERNAME

```
gkd22aa@cip50:~$ ps -u mdd73ak -f
```

UID	PID	PPID	C	STIME	TTY	TIME	CMD
mdd73ak	8010	1	0	09:52	?	00:00:00	/bin/bash ./task.sh
mdd73ak	9892	8010	99	14:34	?	00:20:52	.././ldms 328292300

```
gkd22aa@cip50:~$ ps -e -l
```

F	S	UID	PID	PPID	C	PRI	NI	ADDR	SZ	WCHAN	TTY	TIME	CMD
4	S	0	1	0	0	80	0	-	485	-	?	00:00:01	init
1	S	0	2	0	0	75	-5	-	0	-	?	00:00:00	kthreadd
1	S	0	3	2	0	-40	-	-	0	-	?	00:00:00	migration/0
1	S	0	4	2	0	75	-5	-	0	-	?	00:00:00	ksoftirqd/0
5	S	0	5	2	0	-40	-	-	0	-	?	00:00:00	watchdog/0
1	S	0	6	2	0	-40	-	-	0	-	?	00:00:00	migration/1
1	S	0	7	2	0	75	-5	-	0	-	?	00:00:00	ksoftirqd/1

```
gkd22aa@cip50:~$ ps -p 1 -f
```

UID	PID	PPID	C	STIME	TTY	TIME	CMD
root	1	0	0	Dec08	?	00:00:01	init [2]

```
kill -s [SIGNAL] PID
```

- send a signal to a process (PID)
- [SIGNAL]
 - ▶ QUIT
 - ▶ quit process
 - ▶ KILL
 - ▶ kill process (terminate immediately)
 - ▶ STOP
 - ▶ stop process
 - ▶ CONT
 - ▶ continue process

```
gkd22aa@cip50:~$ wget \
  http://www.geophysik.uni-muenchen.de/~oeser/LV/Shell/rechne
gkd22aa@cip50:~$ chmod 700 rechne
gkd22aa@cip50:~$ ./rechne &
gkd22aa@cip50:~$ top

gkd22aa@cip50:~$ kill -s STOP 18148
[1]+  Stopped                  ./rechne
gkd22aa@cip50:~$ ps -l -C rechne
F S   UID    PID  PPID  C PRI NI ADDR SZ WCHAN TTY          TIME CMD
0 T  24053  18148 17982  77   80  0  -   23  -      pts/1  00:00:42 rech
gkd22aa@cip50:~$ kill -s CONT 18148
gkd22aa@cip50:~$ ps -l -C rechne
F S   UID    PID  PPID  C PRI NI ADDR SZ WCHAN TTY          TIME CMD
0 R  24053  18148 17982  66   80  0  -   23  -      pts/1  00:00:46 rech
```

Background processes and process priority

- `COMMAND &`
 - ▶ command starts in background (fg, bg and jobs)
- `nohup COMMAND`
 - ▶ run a command immune to hangups, with output to a non-tty
- `nice -n VALUE COMMAND`
 - ▶ run a program with modified scheduling priority

```
gkd22aa@cip50:~$ nohup xclock &
[1] 10354
gkd22aa@cip50:~$ nohup: appending output to 'nohup.out'
[STRG-D]
...
gkd22aa@cip50:~$ nice -n 19 iceweasel &
gkd22aa@cip50:~$ ps -f -C iceweasel
```

Access to remote machines

```
ssh [OPTION] HOSTNAME [COMMAND]
```

- logging into a remote machine
- secure encrypted communications between untrusted hosts over an insecure network
- [OPTION]
 - ▶ `-x -X`
 - ▶ disable/enables X11 forwarding
 - ▶ `-l USERNAME`
 - ▶ specifies the user to log in as on the remote machine USERNAME
- HOSTNAME
 - ▶ connect to specified remote machine (FQDN)
- [COMMAND]
 - ▶ if specified, it's executed on the remote host instead of a login shell


```
gkd22aa@cip50:~$ ssh -X cip76
Last login: Fri Dec 11 14:19:43 2009 from cip50.cipmath.loc
gkd22aa@cip76:~$ xclock
[STRG-C]
gkd22aa@cip76:~$ ssh -x cip52 xeyes
Error: Can't open display:
gkd22aa@cip76:~$ ssh -l $USER cip30 'ps -f -u $LOGNAME'
UID          PID  PPID  C  STIME TTY          TIME CMD
gkd22aa  5390  5387  0  15:37 ?        00:00:00 sshd: gkd22aa@notty
gkd22aa  5393  5390  0  15:37 ?        00:00:00 ps -f -u gkd22aa
gkd22aa@cip76:~$ ssh cip52
gkd22aa@cip52:~$ echo $HOSTNAME
cip52
gkd22aa@cip52:~$ exit
logout
Connection to cip52 closed.
```

```
sftp [USERNAME@]HOSTNAME[:DIRECTORY]  
scp [USERNAME@] [HOSTNAME:]SOURCE] \  
    [USERNAME@] [HOSTNAME:]DESTINATION
```

- secure copy (remote file copy program)
- [USERNAME]
 - ▶ specifies the user to log in as on the remote machine USERNAME
- HOSTNAME
 - ▶ connect to specified remote machine (FQDN)
- [DIRECTORY]
 - ▶ replaced with directory on the remote machine
- [SOURCE] [DESTINATION]
 - ▶ replaced with directory or filenames on the local or remote machine

```
gkd22aa@cip50:~$ sftp cip34
Connecting to cip34...
sftp> put ex-1.xyz ex1.dat
Uploading ex-1.xyz to /home/cip/gkd22aa/ex1.dat
ex-1.xyz                                100% 565 0.6KB/s 00:00
sftp> get ex-2.xyz ex2.dat
Fetching /home/cip/gkd22aa/ex-2.xyz to ex2.dat
/home/cip/gkd22aa/ex-2.xyz    100% 797 0.8KB/s 00:00
sftp> ls
Desktop ex-1.xyz ex-2.xyz ex1.dat ex2.dat copy.txt maildir ort_e
sftp> exit
gkd22aa@cip50:~$ scp $USER@cip76:~/ex-1.xyz Desktop/
ex-1.xyz  100% 565 0.6KB/s 00:00
gkd22aa@cip50:~$ scp copy.txt $USER@cip76:~/neu.dat
copy.txt 100%  90 0.1KB/s 00:00
```

Redirect input and output

```
COMMAND < FILE  
COMMAND > FILE  
COMMAND >> FILE  
COMMAND 2> FILE  
COMMAND > FILE 2>&1
```

- redirect standard input, output and error messages
- flexible handling of file contents
 - ▶ COMMAND
 - ▶ replaced with any command
 - ▶ FILE
 - ▶ replaced with filename

```
gkd22aa@cip50:~$ env > output.dat
gkd22aa@cip50:~$ ps -u $USER -f >> output.dat
gkd22aa@cip50:~$ grep gkd < output.dat
USER=gkd22aa
MAIL=/var/mail/gkd22aa
PWD=/home/cip/gkd22aa
HOME=/home/cip/gkd22aa
LOGNAME=gkd22aa
gkd22aa    4675    4668    0 14:23 ?          00:00:00 sshd: gkd22aa@pt
gkd22aa    4676    4675    0 14:23 pts/0      00:00:00 -bash
gkd22aa@cip50:~$ grep gkd < output.dat > hits.dat
gkd22aa@cip50:~$ cat hits.dat
...
gkd22aa@cip50:~$ grep gkd output.dar > hits.dat 2> errors.dat
gkd22aa@cip50:~$ cat errors.dat
grep: output.dar: No such file or directory
```

Summary

- important things to remember:
 - ▶ GNU/Linux command syntax
 - ▶ how to get help and documentation
 - ▶ absolute and relative path
 - ▶ characters with special meaning for the shell
 - ▶ how to work with variables
- Questions?

Generic Mapping Tools



- initiated in 1987 at Lamont-Doherty Earth Observatory, Columbia University by graduate students Paul Wessel and Walter H. F. Smith
- follows UNIX philosophy – complex tasks are broken down into smaller and more manageable components
- offers unlimited flexibility (can be called from the command line, inside scripts, and from user programs)
- attracted many users because of its high quality PostScript output

GMT Documentation

- "Technical Reference and Cookbook"
 - ▶ in [Internet](#)
 - ▶ on [Hard Disk](#)
- "Ä Map-making Tutorial"
 - ▶ in [Internet](#)
 - ▶ on [Hard Disk](#)
- "GMT Online Man Pages"
 - ▶ in [Internet](#)
 - ▶ on [Hard Disk](#)
- "GMT Supplemental Online Man Pages"
 - ▶ in [Internet](#)
 - ▶ on [Hard Disk](#)

First Steps with GMT

- let's work with "A Map-making Tutorial":
 - Session 1: basics and map projections
 - Session 2: psxy, pscoast and pstext
 - Session 3: gridding with grdcontour, xyz2grd, nearneighbor and surface
 - Session 4: color palette tables and color images
- examples from Geophysics and Geology:
 - ▶ <http://www.geophysik.uni-muenchen.de/~oeser/LV/GMT/>

Tutorial Perparation

- please open in browser:
 - ▶ `/usr/share/doc/gmt/html/GMT_Tutorial.html`
- type in terminal (CLI):

```
gkd12ca@cip50:~$ cp -r /usr/share/doc/gmt-tutorial/tutorial/ .
gkd12ca@cip50:~$ cd tutorial/
gkd12ca@cip50:~/tutorial$ gunzip *.gz
gkd12ca@cip50:~/tutorial$ ls
bermuda.grd data quakes.cpt quakes.ngdc ship.xyz topo.cpt us.grd
```

- always prepend to all **GMT** commands the wrapper script GMT

```
gkd12ca@cip50:~$ GMT pscoast ...
gkd12ca@cip50:~$ GMT psxy ...
```

Python

- python lecture material available at:
 - ▶ <http://www.geophysik.uni-muenchen.de/~oeser/LV/Python/>
 - ▶ please store all .tar.gz files on local disk

```
gkd12ca@cip50:~$ virtualenv --system-site-packages $HOME/mypython
gkd12ca@cip50:~$ echo "PATH=$HOME/mypython/bin:$PATH" >> .bashrc
gkd12ca@cip50:~$ tar -xzf Python*.tar.gz
gkd12ca@cip50:~$ cd PythonIntro
gkd12ca@cip50:~/PythonIntro$ ipython notebook
```

- [https://en.wikipedia.org/wiki/Python_\(programming_language\)](https://en.wikipedia.org/wiki/Python_(programming_language))