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Matthias Eulert, Kevin Lüdemann

Linux Shell Crash Course

Surviving the Terminal

Learning Objectives

- Connect to GWDG machines via SSH and access the command line interface
- Navigate the operating system on Linux using the Bash shell
- Edit files using Nano text editor
- Solve routine tasks by formulating commands and combining programs

Preface

- Focus on most important commands
- Additional content for advanced users
- Use this slide deck as lookup during course
- Available for download on course page:
https://hps.vi4io.org/teaching/summer_term_2024/pchpc
- ← Red box marks a command that you want to remember
- Other commands are nice to know
- Presentation accompanied by exercises
- Support room: <https://meet.gwdg.de/b/jul-ffv-ljs-7u5>

What is a Shell?

- A shell is a command line interpreter
- It takes commands entered via the keyboard to start programs
- **Bash** is the most widespread shell
- A **terminal** is an input/output environment for shells
- The mouse can still be used to select text for copy and paste
- The shell is only an interface through which other programs are started
- A shell can only show textual output

Open a shell:

- **Windows:** `WIN` + `r`, type `powershell` and press enter
- **MacOS:** Search for **Terminal** and open it

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SSH Client

Windows 10/11:

- Search for **Powershell**, right click, run as administrator
- `Get-WindowsCapability -Online|Where-Object Name -like '*SSH*'`
If SSH client is not installed run the following command:
`Add-WindowsCapability -Online -Name OpenSSH.Client~~~~0.0.1.0`
- Confirm that it works with `ssh -V`

MacOS/Linux:

- Search for **Terminal** and open it
- Check your ssh version `ssh -V`

Connecting with SSH

- Generate SSH key `ssh-keygen -t ed25519`
- Follow prompts and save the key
- Open <https://id.academiccloud.de/security>
- Under **SSH Public Keys** add your public key
- SSH keys typically stored under `.ssh` in user home
- Public key ends in `.pub`, e.g., `id_ed25519.pub`
- Find your username on in your email for the project portal, `uNNNNN`
- In PowerShell or Terminal type the following command

```
ssh -i KEYNAME uNNNNN@login-mdc.hpc.gwdg.de \  
-o ProxyCommand='ssh -W %h:%p uNNNNN@login.gwdg.de \  
-i KEYNAME'
```
- If you are already in the GÖNET, you only need the first line

Filesystem Hierarchy

- In Linux, everything is a file
- Directories are separated via `/` (Same for Mac, Windows has `\`)
- For example, `/path/to/my/folder` (directory and folder are used interchangeably)
- `/` is the root directory
- `.` indicates the current folder `./my/folder`
- A path can be absolute (starting with `/`) or relative to the current directory (starting with `.`)
- Parent of current directory is `..`

Basic Command Syntax

- Common syntax for commands is
`COMMAND <-OPTIONS> <ARGUMENTS>`
- A command might take 0 or more options prefixed with a `-` and separated by spaces (long options use `--`)
- A command might take 0 or more arguments separated by spaces
- Arguments can be subcommands that also accept options
- Arguments including spaces must be put in quotes
`"my argument"`
- `" "` allow for variable expansion, `' '` do not

Syntax Example

- First command `echo`
- It prints whatever you type after it
- Try `echo hello world`
- It accepts the option `-e` to enable escape commands
- Try `echo -e "hello\nworld"` (try without `-e`)

Shell Shortcuts Basics

- `TAB` Auto-complete file/directory names and commands
- `TAB` + `TAB` Show all possibilities
- `CTRL` + `c` Abort current running process
- `ARROW UP/DOWN` Cycle through command history
- `clear` Clear screen
- `exit` Close current shell session

Shell Shortcuts Advanced

- CTRL + a Jump to line start
- CTRL + e Jump to line end
- ALT + f Jump forward one word
- ALT + b Jump backward one word
- CTRL + u Cut line to clipboard from start up to cursor
- CTRL + k Cut line to clipboard from end to cursor
- CTRL + w Cut word before cursor to clipboard
- CTRL + y Paste from clipboard
- CTRL + s / CTRL + q Stop/Resume output to screen from running process without stopping the process

Folder Navigation

- `pwd` Print current directory
- `ls` List files and folders in current directory
- `ls -a` Also list hidden files and folders (start with `.` marks as hidden)
- `ls -la` List all files and folders in long table format
- `ls -a DIR` List all files and folders in target directory
- `cd DIR` Change directory to target directory
- `cd ~` Change to HOME directory
- `cd ..` Change to parent folder
 - `~` Refers to your HOME folder
 - `.` Refers to the current folder
 - `..` Refers to parent of current folder
- A path including spaces `cd "path/with spaces/"` needs to be put in quotes

Getting help with a command

- `COMMAND --help` , `COMMAND -h` or `COMMAND help` commonly shows usage options
- `man COMMAND` Opens the manual for a command
 - ▶ Mouse wheel for scrolling
 - ▶ `d` / `w` For scrolling down/up
 - ▶ Mouse wheel sometimes does not work via SSH
 - ▶ `q` For quitting the manual
 - ▶ Try `man man`
- `whatis COMMAND` See what pages are available
- `man SECTION COMMAND` Open a specific page for a command
- Search for documentation and guides on the internet

File and Folder Permissions

- Files and folders each belong to a user (owner) and a group
- Read, write and execute permission can be set for owner, group and others
- `ls -l` shows these permissions

d	rwx	---	---	2	linuxuser	UMIN	1	Mar 31 14:42	test
-	-rw	---	---	1	linuxuser	UMIN	16533	Mar 31 14:41	test.txt
type	user perm	group perm	other perm	# of links	owner	group	size	last modified	name

- Type **d** means directory, **-** means file
- Permission **-** means its not set, **r**, **w**, **x** means read, write or execute permission set
- s** or **S** means, when executing, use owner/group permission
- T** means files in folder can only be deleted by their owners

Modifying Permission

- `chmod` Command for changing permission
- `chmod (u|g|o|a)(+|-|=)(r||w||x||) TARGET`
- `chmod a+r test.txt` Gives everyone read permission
- `chmod g= test.txt` Removes all permission for group
- `chmod u+x test` Allows execution of test
- `chmod u+X test-dir` Make directories (but not files) executable/"cd able"
- `chmod -R g+rwX test-dir` Makes test-dir and files and folders in it group readable and writable, **-R** flag makes it recursive
- `chmod +t test-dir` Adds sticky-bit **T** to test-dir
- `chmod u+s test` Use owner permission when executing test

Changing ownership

- `chown NEW_OWNER TARGET` Change the ownership of target
- `chgrp NEW_GROUP TARGET` Change the group of target
- The admin or super-user on Linux systems is called root
- `sudo COMMAND` (super-user do) Execute command as admin
- `whoami` Show own username
- `who` Show logged in users
- `w` More information active users

Nano Basic Usage

- **Nano** is a text editor for the terminal
 - ▶ Relatively easy to use
 - ▶ Alternatives: **emacs**, **vi**, ...
 - ▶ Use your preferred editor
- `nano FILE` To start editing, if file does not exist, its created
- Navigate with `ARROW`-keys and type to edit
- `CTRL + o` To save as...
- `CTRL + s` To save (HPC machines have old nano, use `CTRL + o` instead)
- `CTRL + x` To exit

Nano Shortcuts 1/2

- `ESC` Can be used instead of `ALT`
- `CTRL + w` Open search
- `ALT + w` Continue search
- `CTRL + w`, `CTRL + R` Open search and replace
- `CTRL + c` Cancel command
- `ALT + a` Set mark for selection
- `ALT + 6` Copy selected text (area between mark and cursor) to clipboard
- `CTRL + k` Cut current line or selected text to clipboard
- `CTRL + u` Paste clipboard at cursor

Nano Shortcuts 2/2

- ALT + u/e Undo/Redo
- CTRL + a/e Jump to line start/end
- CTRL + y/v Scroll page up/down
- CTRL + g Open help window
- CTRL + o Save as..
- CTRL + c Show cursor position
- CTRL + 7 Jump to line number
- ALT + o Enable/Disable conversion of tabs to spaces

Environmental Variables

- Values can be stored in environmental variables
- Some are used for configurations
- `echo $HOME` To see the value of HOME
- `echo -e ${PATH//:/:\n}` To get a nice output for PATH
- `printenv` or `set` to see all current env vars
- `export NAME=Value` Set variable, no spaces before or after =
- `unset NAME` Unset variable
- Env vars are bound to your session and do not persist after session ends

Persistent settings

- When you login into a Bash shell, it reads `.bash_profile`
- When you open another Bash shell without login, it reads `.bashrc`
- `nano .bash_profile` Open bash profile and make it load `.bashrc`
- Add this line to it `[[-f ~/.bashrc]] && . ~/.bashrc` and save
- `nano .bashrc` To start editing
- Add `export HELLO=hi`
- `alias` Can be used to set command aliases
- Add `alias ll='ls -la'` and save
- `source .bashrc` To load the changes now

Custom Prompt

- By setting the env var `PS1` you can customize your prompt
- Try `export PS1='[\t] \u@\h:\w$'`
- `\t` Gives the current time
- `\u` Gives your username
- `\h` Gives the hostname
- `\w` Gives the current folder
- Search for **bash ps1 generator** on the internet

Create, Copy, Move, Delete

- `touch FILE` Update modification time of file or create empty file
- `rm -i FILE` Delete file with confirmation, confirm with `y`
- `mkdir DIR` Create directory
- `rmdir DIR` Delete directory
- `rm -rf DIR` Delete everything in folder (sub-folders, files, ...) use with **great care**, there is **no undo**
- `cp SRC DEST` Copy a file from source to destination
- `cp -R SRC DEST` Copy folders including sub-folders
- `mv SRC DEST` Move a file or folder, also functions as rename

Disk Usage

- `ls -lh` List directory with human-readable sizes
- `du -h DIR` Show size of target folder and sub-folders
- `du -hd1` Do not show size of sub-folders
- `stat TARGET` Show details including size of file oder folder
- `df -hl` Show filesystem usage, look for filesystem mounted on /
- `tree` Show tree representation of sub-folders
- `show-quota`

Read and Search Files

- `cat FILE` Print file content to shell
- `less FILE` Show file content with pager
- `find PATH -name '*.txt'` Find all txt files in path
- `grep PATTERN FILE` Search for pattern in file
- `grep -R PATTERN PATH` Search for pattern in all files in path
- `locate NAME` Find files containing NAME in their filename
- `head FILE` Show first 10 lines of file
- `tail FILE` Show last 10 lines of file
- `diff FILE1 FILE2` Compare files and list differences

Processes

- `top` or `htop` Show current resource usage by processes
Use `htop` over `top`, close with `q` or `CTRL` + `c`
- `ps` List all processes on current shell session
- `ps -u USER` List all processes by a specific user, try `ps -u root`
- `ps aux` or `ps -ef` List all processes by all users
- `kill PID` Stop process with process id
- `COMMAND1 && COMMAND2` Lets you chain multiple commands
this will execute `COMMAND1` and then `COMMAND2`
but only if `COMMAND1` succeeded

Jobs

- `COMMAND &` Let the command execute as a background job
- `CTRL + z` Stop and make the running command a background job
- `jobs` List your background jobs
- Jobs are bound to your shell session, all jobs are killed when you close your shell
- `bg %JOB_NUM` Start a stopped background job
- `fg %JOB_NUM` Move a job into the foreground
- `disown %JOB_NUM` Disown a job from your shell, keeps it running after closing shell

Gain Information on Host System

- `hostname` Show hostname of system
- `uname -a` Show kernel information
- `cat /etc/os-release` , `hostnamectl` , `lsb_release -a`
Show kernel and distribution information
- `uptime` Show system uptime, time since last restart

Redirect Command Outputs

- `COMMAND > FILE` Redirects the output of command into file
- `>` Creates or overwrites file, `>>` creates or appends file
- `|` A pipe that forwards inputs from one command into another
- `ps aux | grep PATTERN` Filter the output of a command using grep
- `COMMAND | sort -u` Sort and filter unique lines in output
- Only the output of the last command is shown in the shell

Bash History

- `history` List all previous commands
- `history -c` Clear history (in case you entered your password)
- `history | grep PATTERN` Look for a command you used before
- `!N` Expands to line n of your bash history
- `!!` Expands to previous command
- `!TEXT` Expands to last command starting with text
- `!?TEXT` Expands to last command containing text
- `!#:N` Expands to nth argument of current command, can be used like this:
 - ▶ `mkdir NEW_DIR && cd !#:1` to create and switch to new dir

Shell Scripting

- Bash commands can be used to program shell scripts
- Written in plain text and saved as `.sh` files
- Must have as first line `#!/usr/bin/bash`
- You can use loops, conditions and so on like a regular programming language
- Make it executable if it isn't `chmod +x script.sh`
- Run a script using `./script.sh`
- First inspect a script `less script.sh` or `nano script.sh` before running it
- Commonly used to start jobs on supercomputers

Downloading things from the internet

- `wget URL` Download a file at the target URL and save it to disk
- `wget -O NAME URL` Download a file and set its name
- `curl URL` Download a file at the target URL and show it in shell
- `curl -o NAME URL` Download file at URL to a file with name
- Both `curl` and `wget` support HTTP(S) and FTP
- `curl` also supports other protocols and making custom requests
- Common compressions of downloadable files: `tar.gz` or `zip`
- `tar -xzvf FILE.tar.gz` Extracts contents of file to local folder
- `unzip FILE.zip` Extract contents of file to local folder

Summary part 1

- You learned how to navigate in the shell
- You learned about getting help
- You learned about editors
- You learned about environments and variables
- You learned about processes
- You learned about scripts

Learning Objectives

- Become acquainted with the Linux OS
- Get to know some desktops
- Explore Linux and how it handles hardware
- Learn about working with linux

Table of contents

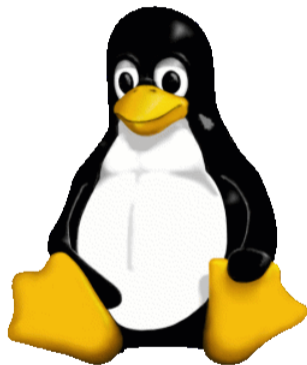
18 Overview

19 Linux Desktop

20 Linux System

What is a Linux

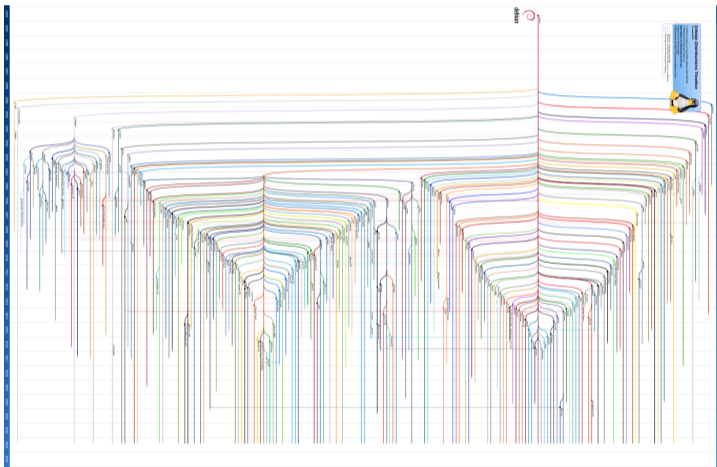
- Originally developed by Linus Torvalds in *1991*
- Open Source operating system
<https://github.com/torvalds/linux>
- Available under GPL-2.0 license
- Commonly bundled as Linux Distributions
(Ubuntu, Debian, Red Hat, Arch, ...)
- Omnipresent in HPC and servers



Tux - Linux mascot

Image source: [https://en.wikipedia.org/wiki/Tux_\(mascot\)#/media/File:Tux.png](https://en.wikipedia.org/wiki/Tux_(mascot)#/media/File:Tux.png)

Debian+Ubuntu Family tree

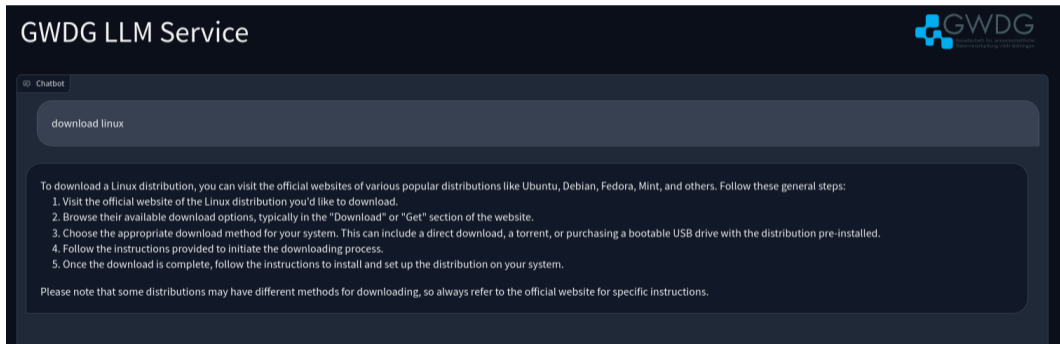


https://en.wikipedia.org/wiki/List_of_Linux_distributions

Desktop Environment (DE)

- Unlike Windows or Mac, multiple DEs supported
- Most popular: GNOME, KDE
- DE (mostly) independent of Linux distribution
- Highly customizable
 - ▶ Window management and alignment
 - ▶ Replace file explorer, login manager, ...
- Checkout what others use: <https://www.reddit.com/r/unixporn/>

Linux Desktop - Where to get



GWDG LLM Service

Chatbot

download linux

To download a Linux distribution, you can visit the official websites of various popular distributions like Ubuntu, Debian, Fedora, Mint, and others. Follow these general steps:

1. Visit the official website of the Linux distribution you'd like to download.
2. Browse their available download options, typically in the "Download" or "Get" section of the website.
3. Choose the appropriate download method for your system. This can include a direct download, a torrent, or purchasing a bootable USB drive with the distribution pre-installed.
4. Follow the instructions provided to initiate the downloading process.
5. Once the download is complete, follow the instructions to install and set up the distribution on your system.

Please note that some distributions may have different methods for downloading, so always refer to the official website for specific instructions.

Linux Desktop - Ubuntu flavors

The screenshot shows the Linux.org website's 'Download Linux' page. The page features a navigation bar with 'Forums', 'What's new', 'Linux Tutorials', 'Members', 'Download Linux', 'Newsletter', 'Credits', and 'LUGs'. Below the navigation bar, there is a search bar and a 'New posts' link. The main content area is titled 'Download Linux' and includes a sub-header '24 Popular Linux Distributions'. A text block below the sub-header reads: 'Explore different Linux distributions and find the one that fits your needs. Try distrowatch.com for more options.' The page displays 12 distribution cards in a 3x4 grid, each with a logo, name, and a 'Download' link. The distributions shown are: Ubuntu, CentOS, Debian, Fedora, Slackware, Mint, Xubuntu, Arch, OpenSuse, RedHat, Slackel, and PureOS. A sidebar on the right contains a 'SUPPORT LINUX.ORG MAKE A DONATION TODAY' banner.

LINUX.ORG













Forums | What's new | Linux Tutorials | Members | Download Linux | Newsletter | Credits | LUGs | Log in | Register | Search

Forums > General Linux Forums > Download Linux

Links to popular distribution download pages

24 Popular Linux Distributions

Explore different Linux distributions and find the one that fits your needs. Try [distrowatch.com](#) for more options.

 Ubuntu Download Ubuntu	 CentOS Download CentOS	 Debian Download Debian	 Fedora Download Fedora
 Slackware Download Slackware	 Mint Download Mint	 Xubuntu Download Xubuntu	 Arch Download Arch
 OpenSuse Download OpenSuse	 RedHat Download RedHat	 Slackel Download Slackel	 PureOS Download PureOS

SUPPORT LINUX.ORG
MAKE A DONATION TODAY

Linux Desktop - VirtualBox

- Add new - Enter name, Linux, flavor
- Recommended is 2048MB but better is 4096MB RAM
- Create new HDD file now
 - ▶ Choose VDI
 - ▶ Dynamics allocation
 - ▶ At least 20GB of free space
- Later you may want to increase the number of Cores

Linux Desktop - VirtualBox

The screenshot displays the Oracle VM VirtualBox interface. On the left, a list of virtual machines is shown, with 'PCPCC' selected and its settings window open. The 'Storage' tab is active, showing a storage controller named 'Controller: IDE' with a single attached disk, 'PCPCC-disk1.vdi'. A red '2.' is overlaid on the 'Storage' tab in the left sidebar.

In the center, the 'PCPCC - Optical Disk Selector' dialog is open. It shows a table of available optical disk images:

Media	Virtual Size	Actual Size
3		
Started		
ubuntu-23.10-desktop-amd64.iso	4.82 GB	4.82 GB
ubuntu-23.10-desktop-amd64.iso	2.96 GB	2.96 GB

Buttons for 'Add', 'Create', and 'Refresh' are visible. A red '3.' is overlaid on the 'Add' button.

At the bottom right, a file selection dialog titled 'Please choose a virtual optical disk file' is open. It shows a list of files in the 'Downloads' folder:

Name	Size	Type	Date Modified
ubuntu-23.10-desktop-amd64.iso	4.82 GB	iso file	13.09.24 11:07
ubuntu-23.10-desktop-amd64.iso	2.96 GB	iso file	13.09.24 10:47

A red '4.' is overlaid on the file list. The 'File name' field contains 'ubuntu-23.10-desktop-amd64.iso' and the 'Files of type' dropdown is set to 'All virtual optical disk files (*.dmg *.iso *.vdi)'. A 'Preview' window on the far right shows a black screen with the text 'PCPCC'.

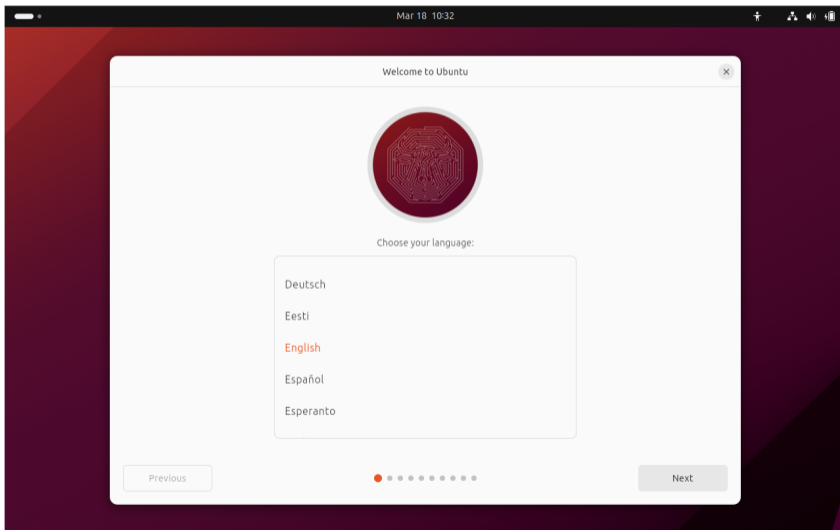
Linux Desktop - Install

```
GNU GRUB  version 2.12~rc1

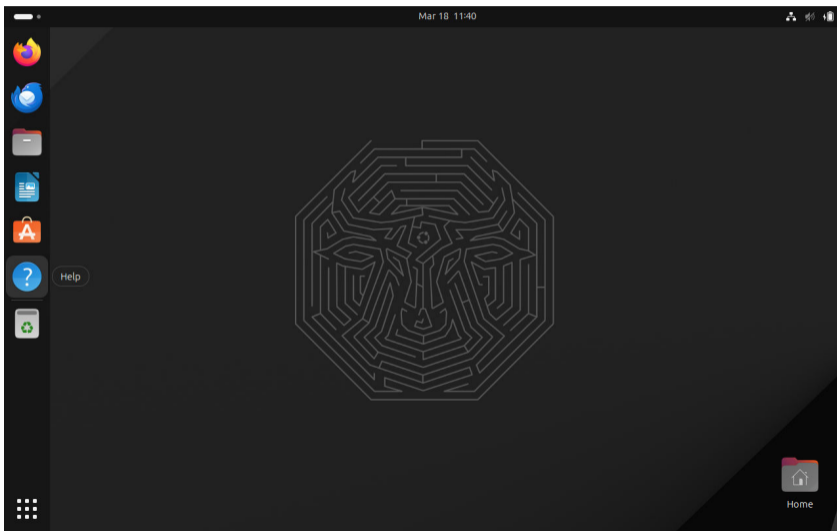
*Try or Install Ubuntu
Ubuntu (safe graphics)
Test memory

Use the ↑ and ↓ keys to select which entry is highlighted.
Press enter to boot the selected OS, 'e' to edit the commands
before booting or 'c' for a command-line.
The highlighted entry will be executed automatically in 26s.
```

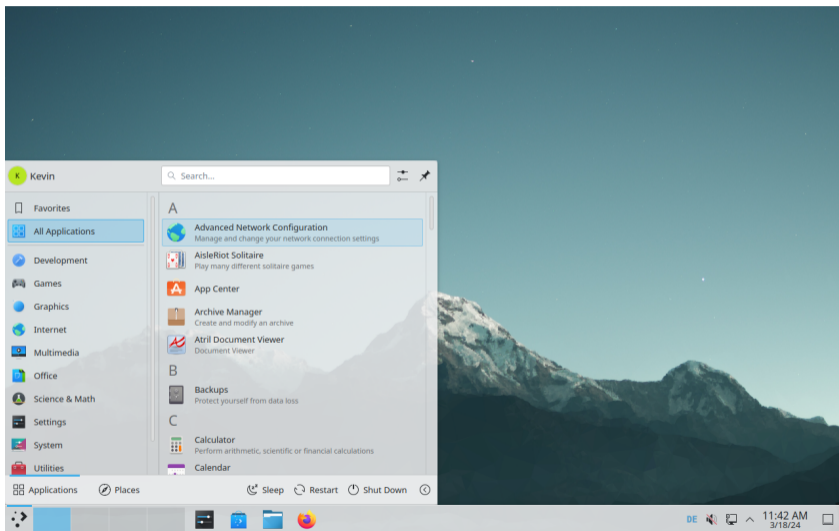
Linux Desktop - Install



Linux Desktop - Example desktop: GNOME 3



Linux Desktop - Example desktop: KDE plasma



Linux Desktop - Installing software

- Using package manager
 - ▶ apt, apt-get, packman, yum, dnf
 - ▶ snap and snap packages
 - ▶ flatpack
- Compiling from source (someone said gentoo??)
- Software manager APP

Linux Desktop - App/Software center

The screenshot shows the Linux Desktop App/Software Center window. The title bar indicates the date and time as "Mar 18 16:35". The window has a search bar at the top with the text "Search for apps". On the left side, there is a vertical sidebar with several icons: a red and yellow flame (GNOME), a blue speech bubble (Mutter), a blue document (Files), a blue document with a pencil (Development), an orange shopping bag (App Center), a red and white lifebuoy (Help), and a grey trash can (Trash). Below these icons are three buttons: "Explore" (selected), "Featured", "Productivity", "Development", and "Games". At the bottom of the sidebar are "Manage" and "About" buttons. The main content area features a large purple and teal banner with the text "Jump start your desktop" and a "Discover more" button. Below the banner are six application cards, each with an icon, name, developer, description, and user ratings:

- Transmission** by Sameer Sharma: Download and share files over BitTorrent. Very good | 129 votes.
- Cheese** by Ken VanDine: Take photos and videos with your webcam, with fun graphical effects. Good | 66 votes.
- remmina** by Remmina Upstream Developers: Remote Desktop Client. Good | 82 votes.
- GNOME Calendar** by Canonical: Calendar for GNOME. Good | 126 votes.
- GNOME Mahjongg** by Ken VanDine: Match tiles and clear the board. Good | 35 votes.
- GNOME Mines** by Ken VanDine: Clear hidden mines from a minefield. Insufficient votes | 20 votes.

Linux Desktop - Want to play games

The screenshot shows a Linux desktop environment with a dark theme. On the left is a vertical dock with icons for Firefox, Telegram, a file manager, a terminal, the Ubuntu Software Center, a lifebuoy icon, a trash can, and a grid of application icons. The main window is a browser displaying the Steam application page. The browser's address bar shows 'steam'. The page features the Steam logo, the name 'Steam' by Canonical, and a green 'Install' button. Below this, there are details: 809 votes (Good), Confinement: Strict, Download size: 201.39 MB, License: Proprietary, Version: 1.0.0.78, and Published: Dec 11, 2023. There are also links for the Developer website and Contact Canonical. A 'Gallery' section is partially visible at the bottom, showing a preview of the Dota 2 game page.

File System

- Many different file system (FS) implementations exist
- Some support **Journaling**
 - ▶ FS keeps a log (journal) of file operations
 - ▶ Enables consistency in case of crash during write
- Some are better for parallel IO
- NFS for network mounting
- See currently mounted FS via
 - ▶ `df -T`

File System Types - Examples

■ ext4

- ▶ Native Linux FS

■ XFS

- ▶ High-performance FS

■ BeeGFS

- ▶ High-performance parallel File system

■ NTFS/FAT

- ▶ Windows FS
- ▶ USB-Sticks, ...

■ HFS+

- ▶ Mac FS

■ tmpfs

- ▶ Linux temporary in-memory FS

Linux File Tree

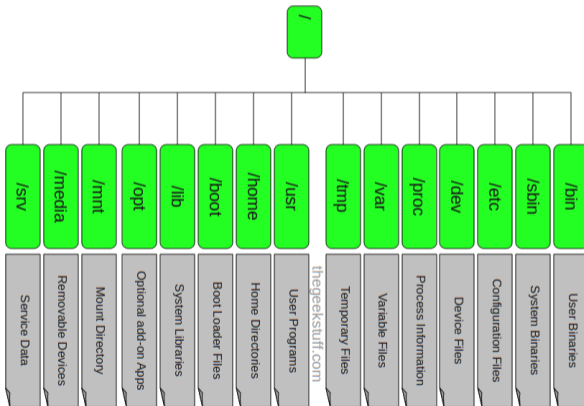


Image source: <https://static.thegeekstuff.com/wp-content/uploads/2010/11/filesystem-structure.png>

System Logging

- Logs commonly in `/var/log`
 - ▶ Find application and system logs here
 - ▶ Use `tail -f file` to follow changes
- `dmesg` print Kernel ring buffer
- `journalctl` for systemd logs

Linux Services and systemd

- Service management software (controversial but works)
- Interaction commands are:
 - ▶ `systemctl status`
 - ▶ `systemctl start/stop`
 - ▶ `systemctl enable/disable`
 - ▶ `systemctl --user`
- Try it out for these services
 - ▶ `systemctl status sshd`
 - ▶ `systemctl status ntpd`

Linux hardware files

■ Mounting hard drives and USB Sticks

- ▶ Find devices using `lsblk`
- ▶ Mount a device `mount /dev/sda1 /mnt`
- ▶ Unmount a device `umount /mnt`

■ Finding the Battery

- ▶ Could be at `/sys/class/power_supply/BAT0/`
- ▶ Current status `charge_now`

■ Finding the CPU `lscpu` / `cat /proc/cpuinfo`

- ▶ Could be at `/sys/devices/system/cpu/cpu0/cpufreq/`
- ▶ Current frequency `scaling_cur_freq`

Summary part 2

- You learned the beauty of Linux desktops
- You learned how to install software
- You should be able to find hardware files