Linux - Administration

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Program

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Program

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Installation and Configuration

Overview of Server Operating Systems

OVERVIEW OF SERVER OPERATING SYSTEMS

What Makes a Server OS Different?

- Stability and uptime
- Security
- Resource efficiency
- Remote management

Common Server Operating Systems

Linux Distributions

- Ubuntu Server
- Debian
- CentOS / Rocky Linux / AlmaLinux
- Red Hat Enterprise Linux (RHEL)
- SUSE Linux Enterprise Server (SLES)

Key Considerations When Choosing a Server OS

- Hardware compatibility
- Cost
- Available community or vendor support

💻 Common Server Operating Systems

✅ Linux Distributions (Distros)

Linux is a top choice for servers due to its **open-source nature, stability, performance**, and **flexibility**.

- **Ubuntu Server**: Easy to use, popular in cloud environments, backed by Canonical.
- **Debian**: Known for stability, ideal for long-term server deployments.
- **CentOS / Rocky Linux / AlmaLinux**: Popular for enterprise environments (Red Hat compatible).
- **Red Hat Enterprise Linux (RHEL)**: Commercial support, widely used in critical systems.
- **SUSE Linux Enterprise Server (SLES)**: Used in enterprises, especially in Europe.

✅ Unix Variants

- **FreeBSD**: Known for performance and advanced networking capabilities.
- **OpenBSD**: Focuses on security and code correctness.

🧠 Key Considerations When Choosing a Server OS

When choosing a server OS, administrators evaluate:

- **Hardware compatibility**
- **Available community or vendor support**
- **Security requirements**
- **Type of services to host (e.g., web, database, file server)**
- **Cost** (license fees vs. open-source)

🛠️ Preparing for Installation and Best Practices

Before installing a Linux server, proper **preparation is essential** to ensure a smooth and secure deployment. This phase helps prevent misconfigurations, hardware compatibility issues, or downtime later in production.

🔹 1. Define the Purpose of the Server

Clearly identify what the server will be used for:

- Web server (Apache, Nginx)
- File server (NFS, Samba)
- Database server (MySQL, PostgreSQL)
- DNS, DHCP, Email, VPN, etc.

Why?

➡️ Because each use case requires different services, configurations, and sometimes different distributions.

🛠️ Preparing for Installation and Best Practices

🔹 2. Choose the Right Linux Distribution

Select a Linux version suited for your goals:

- **Ubuntu Server**: Cloud-friendly, easy to use.
- **Debian**: Stable and reliable.
- **CentOS Stream / Rocky Linux / AlmaLinux**: Enterprise environments.
- **RHEL / SLES**: If you need vendor support.

🛠️ Preparing for Installation and Best Practices

🔹 3. Verify Hardware Requirements

Check:

- CPU architecture (x86_64, ARM)
- RAM (minimum and recommended for your services)
- Disk space
- Network interfaces
- Compatibility (especially for RAID controllers, Wi-Fi cards, GPUs if needed)

Use tools like:

```
lscpu
lsblk
lspci
lsusb
```

🛠️ Preparing for Installation and Best Practices

🔹 4. Plan Your Disk Layout

Decide:

- Separate partitions for `/`, `/home`, `/var`, `/tmp`, `/boot`
- Use of LVM (Logical Volume Manager) for flexibility
- File systems: ext4, xfs, btrfs

Why?

➡️ It helps in isolating logs, backups, user data, and makes maintenance easier.

🛠️ Preparing for Installation and Best Practices

🔹 5. Prepare a Backup Plan (if reusing hardware)

- If you're installing on an existing server, make sure to backup all critical data.
- Test the backup restore procedure!

🔹 6. Plan for Network Configuration

- Static IP or DHCP?
- DNS servers and hostname?
- Firewall ports to open?
- Will the server be accessible from outside?

Prepare your IP settings **before installation**.

🛠️ Preparing for Installation and Best Practices

🔹 7. Choose Installation Method

Depending on the scenario:

- **CD/DVD or USB bootable media**
- **PXE (Preboot Execution Environment)** for mass installations
- **Cloud-init** or preseed/kickstart files for automation

🔹 8. Follow Best Practices

✔ Use only the packages you need (minimal install = fewer attack surfaces)
✔ Use a strong root password or better, disable root login and use `sudo`
✔ Create an unprivileged user during setup
✔ Set up SSH keys instead of passwords
✔ Update the system after installation (`apt update && apt upgrade` or `dnf update`)
✔ Document the configuration and installation steps

🛠️ Preparing for Installation and Best Practices

💻 Installation Process and Troubleshooting

🔹 1. Starting the Installation

Once preparation is done, the installation process begins by:

- **Booting from the installation media** (USB/DVD/ISO)
- Selecting the **language**, **keyboard layout**, and **time zone**
- Choosing between **manual** or **guided partitioning**
- Creating users and setting the root password
- Selecting packages or performing a minimal installation

💡 Most distributions (Ubuntu, Debian, RHEL, etc.) offer both graphical and text-based installation modes.

💻 Installation Process and Troubleshooting

🔹 2. Common Installation Steps

1. **Partition Disks**
   - Use LVM for flexibility
   - Format with `ext4`, `xfs`, etc.
2. **Configure Bootloader**
   - GRUB is usually installed on the main disk (e.g., `/dev/sda`)
3. **Set Up Network**
   - DHCP or static IP configuration
   - Set hostname and DNS
4. **Install Packages**
   - Select predefined sets (server, desktop, minimal)
   - Or choose manually

💻 Installation Process and Troubleshooting

5. **Install Updates**
   - After installation, run:

```
sudo apt update && sudo apt upgrade
```

or

```
sudo dnf update
```

💻 Installation Process and Troubleshooting

🔹 3. Post-Installation Checks

- Can the system boot without error?
- Can you log in via the console or SSH?
- Is the network working?
- Are all partitions mounted correctly?
- Are essential services running?

Use:

```
systemctl status
ip a
df -h
```

🖥️ Installation Process and Troubleshooting

🔧 4. Troubleshooting Installation Issues

Problem	Possible Cause	Solution
💣 Kernel panic	Hardware unsupported or misconfigured bootloader	Try different kernel or boot options
❌ No network	Missing drivers, bad config	Check `ip a`, `dmesg`, network config files
🧱 GRUB not found	Bootloader not installed	Boot from live USB and reinstall GRUB
⛔ Disk not detected	RAID/SATA/NVMe drivers missing	Load appropriate drivers or switch to AHCI in BIOS
🔐 Can’t login	Wrong user/pass or SSH key issue	Boot into recovery mode and reset password

💻 Installation Process and Troubleshooting

🔹 1. Common Boot Issues

🔸 GRUB Bootloader Errors

Symptoms:

- Blank screen or “grub rescue>” prompt after reboot
- “No such partition” or “unknown filesystem”

Causes:

- GRUB was not installed properly
- Wrong boot device selected
- Partition table or boot sector damaged

💻 Installation Process and Troubleshooting

Solutions:

```
# From a Live CD:
sudo mount /dev/sdXn /mnt          # Mount root partition
sudo mount --bind /dev /mnt/dev
sudo mount --bind /proc /mnt/proc
sudo mount --bind /sys /mnt/sys
sudo chroot /mnt
grub-install /dev/sdX
update-grub
```

🖥️ Installation Process and Troubleshooting

🔹 2. Network Issues During Installation

🔸 No network connectivity

Symptoms:

- DHCP fails, no IP assigned
- Can’t update or fetch packages

Causes:

- No drivers for network card
- DHCP server not responding
- Wrong network configuration

💻 Installation Process and Troubleshooting

Solutions:

```
# Check network interfaces:
ip a
# Enable interface manually
sudo ip link set dev eth0 up
# Try restarting DHCP
sudo dhclient eth0
```

> For static IP: manually configure `/etc/network/interfaces` (Debian) or `nmcli` (RedHat-based systems)

💻 Installation Process and Troubleshooting

🔹 3. Disk and Partitioning Issues

🔸 Disk not detected

Symptoms:

- No disk shown in partitioning screen

Causes:

- Missing SATA/RAID/NVMe drivers
- BIOS misconfiguration

Solutions:

- In BIOS/UEFI, set disk mode to **AHCI**
- Use `lsblk`, `fdisk -l`, `dmesg | grep sd` to check device presence
- If using LVM, activate it:

```
vgscan
vgchange -ay
```

💻 Installation Process and Troubleshooting

🔸 Filesystem or partition errors

Symptoms:

- Installation stops at formatting step
- Mount errors during boot

Solutions:

```
# From a live system:
fsck /dev/sdXn
```

💻 Installation Process and Troubleshooting

🔹 4. Installation Freeze or Crash

Symptoms:

- Graphical installer hangs
- Black screen with no logs

Solutions:

- Try **text-based installer** or **alternate ISO**
- Boot with kernel parameters like:
  - `nomodeset` (for graphics)
  - `acpi=off` (for power issues)
  - `noapic` or `nolapic` (for CPU issues)

Edit the GRUB entry by pressing `e` and appending to the `linux` line.

🖥️ Installation Process and Troubleshooting

🔹 5. Password or User Login Issues

Symptoms:

- Can’t log in after reboot
- SSH keys not accepted

Solutions:

- Boot into **recovery mode** or use Live CD:

```
mount /dev/sda1 /mnt
chroot /mnt
passwd yourusername
```

💻 Installation Process and Troubleshooting

🔹 6. Package Installation Failure

Symptoms:

- "Package X could not be installed"
- "Failed to fetch"

Solutions:

- Check internet access
- Verify `/etc/apt/sources.list` or repository configuration
- Clear and retry:

```
sudo apt clean
sudo apt update
```

💻 Installation Process and Troubleshooting

🪵 7. Useful Log Files

- `/var/log/syslog` – system-wide messages
- `/var/log/installer/` – specific to the installation process
- `dmesg` – kernel messages (drivers, devices)
- `journalctl` – on systems using `systemd`

✅ Post-installation Tasks for System Stability

Once Linux is installed, your system is technically operational — but **not production-ready**. There are several essential tasks to ensure **stability, performance, and security** over time.

🔹 1. Update the System Immediately

After installation, the packages may be outdated.

Why?

New vulnerabilities may have been patched or critical updates released.

Commands:

```
# For Debian/Ubuntu
sudo apt update && sudo apt upgrade

# For RHEL-based systems
sudo dnf update
```

✅ Post-installation Tasks for System Stability

🔹 2. Enable and Configure a Firewall

Ensure that only the necessary ports are open.

Tools:

- `ufw` (simple and user-friendly)
- `firewalld` (CentOS, RHEL)
- `iptables` (low-level control)

Example:

```
# For UFW
sudo ufw enable
sudo ufw allow ssh
sudo ufw allow http
```

✅ Post-installation Tasks for System Stability

🔹 3. Disable Unnecessary Services

Each running service increases the **attack surface** and uses system resources.
List services:

```
systemctl list-units --type=service
```

Disable unnecessary ones:

```
sudo systemctl disable bluetooth.service
```

✅ Post-installation Tasks for System Stability

🔹 4. Set Up Automatic Security Updates

To keep your system safe over time, configure unattended upgrades.

Ubuntu/Debian:

```
sudo apt install unattended-upgrades
sudo dpkg-reconfigure unattended-upgrades
```

RHEL-based (with dnf-automatic):

```
sudo dnf install dnf-automatic
sudo systemctl enable --now dnf-automatic.timer
```

✅ Post-installation Tasks for System Stability

🔹 5. Create Regular Users and Disable Root SSH Login

Using root is dangerous. Instead, use a non-root user with `sudo`.

```
sudo adduser adminuser
sudo usermod -aG sudo adminuser
```

Then edit `/etc/ssh/sshd_config`:

```
PermitRootLogin no
```

Restart SSH:

```
sudo systemctl restart ssh
```

✅ Post-installation Tasks for System Stability

🔹 6. Configure Time Synchronization (NTP)

Correct time is crucial for logs, authentication, cron jobs, etc.
Recommended service:

```
sudo timedatectl set-ntp true
```

To verify:

```
timedatectl status
```

✅ Post-installation Tasks for System Stability

🔹 7. Set Up Monitoring and Logging

Install tools to monitor:

- CPU, memory, disk (e.g., `htop`, `iotop`)
- Services (`systemctl`, `journalctl`)
- Remote logging (e.g., rsyslog, syslog-ng, or forwarding to Splunk/Grafana)

✅ Post-installation Tasks for System Stability

🔹 8. Schedule Backups

Plan for failure. Even stable systems can crash.

- Backup `/etc`, user data, databases
- Use tools like `rsync`, `borg`, or `tar`
- Automate with `cron` or systemd timers

✅ Post-installation Tasks for System Stability

🔹 9. Enable Swap (if needed)

Some systems don't create swap by default.
Check:

```
swapon --show
```

If no swap:

```
sudo fallocate -l 2G /swapfile
sudo chmod 600 /swapfile
sudo mkswap /swapfile
sudo swapon /swapfile
echo '/swapfile none swap sw 0 0' | sudo tee -a /etc/fstab
```

✅ Post-installation Tasks for System Stability

🔹 10. Harden the System

- Use tools like **Lynis** to audit the system:

```
sudo apt install lynis
sudo lynis audit system
```

- Disable unnecessary kernel modules
- Configure SELinux (RHEL) or AppArmor (Ubuntu)

⚙ Basic System Configuration

After installing the system, some initial configuration is required to ensure the server runs reliably, follows organizational standards, and is ready for further deployment.

🔹 1. Set the Hostname

The hostname is the unique name assigned to your machine within the network or your infrastructure.
It is used in logs, SSH sessions, and prompt appearance (`user@hostname`).
To view the current hostname:

```
hostnamectl
```

To change it:

```
sudo hostnamectl set-hostname server01
```

“ Optionally, update `/etc/hosts` to reflect the new name: ”

```
127.0.0.1   localhost
127.0.1.1   server01
```

2. Configure the System Time and Timezone

Accurate system time is crucial for:

- Log file timestamps
- Scheduled tasks (cron jobs)
- Authentication and security mechanisms
- Synchronizing distributed systems

Check current settings:

```
timedatectl
```

Set your timezone (example for New York):

```
sudo timedatectl set-timezone America/New_York
```

“ To list all available time zones: ”

```
timedatectl list-timezones
```

Enable time sync with NTP:

```
sudo timedatectl set-ntp true
```

3. Configure the System Locale and Keyboard Layout

Setting the correct locale ensures that your system:

- Displays characters correctly
- Sorts text based on your language
- Uses the right number/date formats

View current locale:

```
locale
```

Reconfigure (Debian-based):

```
sudo dpkg-reconfigure locales
```

Generate missing locales:

```
sudo locale-gen en_US.UTF-8
```

Keyboard configuration (Debian):

```
sudo dpkg-reconfigure keyboard-configuration
```

4. Configure the Bootloader (GRUB)

It’s important to ensure that your bootloader is correctly installed and configured.

To view GRUB config (Debian/Ubuntu):

```
cat /boot/grub/grub.cfg
```

To update GRUB:

```
sudo update-grub
```

To reinstall GRUB (if needed):

```
sudo grub-install /dev/sda
sudo update-grub
```

You can also customize:

- Default kernel
- Timeout
- Splash screen
- Kernel boot parameters

Edit `/etc/default/grub` and then run `update-grub`.

5. Enable and Configure Logging

System logs help you monitor system behavior and diagnose issues.
Systemd-based systems use `journald`:

- View logs:

```
journalctl
```

- Logs persist across reboots:

```
sudo mkdir -p /var/log/journal
sudo systemd-tmpfiles --create --prefix /var/log/journal
sudo systemctl restart systemd-journald
```

Also check log rotation:

- Managed by `logrotate`
- Configured in `/etc/logrotate.conf` and `/etc/logrotate.d/`

Test log rotation:

```
sudo logrotate --debug /etc/logrotate.conf
```

7. Review Kernel Modules

Only necessary kernel modules should be loaded.
List loaded modules:

```
lsmod
```

To remove one (example: `bluetooth`):

```
sudo modprobe -r bluetooth
```

You can blacklist modules you don’t want at boot by editing `/etc/modprobe.d/blacklist.conf`.

8. Configure System Services

Ensure critical services are **enabled**, and unnecessary ones are **disabled**.

View running services:

```
systemctl list-units --type=service
```

Enable a service (example: cron):

```
sudo systemctl enable --now cron
```

Disable a service (example: cups if unused):

```
sudo systemctl disable --now cups
```

9. Set Up Log Monitoring Alerts (Optional for long-term stability)

Advanced setups include installing lightweight log monitoring tools like:

- `logwatch`
- `logcheck`

These can email you daily summaries of system events, helping to catch early signs of problems.

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Identity Management

🔹 1. User and Group Management

✅ Types of Users

- **Root (UID 0):** full control of the system.
- **System users (UID < 1000):** created by services like `mysql`, `www-data`.
- **Regular users (UID ≥ 1000):** human users.

📁 Key Files

File	Description
`/etc/passwd`	Basic user info (username, UID, shell, etc.)
`/etc/shadow`	Encrypted passwords + password policies
`/etc/group`	List of groups and members
`/etc/gshadow`	Secure group passwords

🔹 1. User and Group Management

🛠️ User Commands

Task	Command
Add user (with home)	`adduser alice`
Add user (manual)	`useradd -m alice`
Delete user	`deluser alice` or `userdel alice`
Delete user and home	`userdel -r alice`
Modify user	`usermod` (e.g. `usermod -l newname oldname`)
Set password	`passwd alice`
View user info	`id alice` or `getent passwd alice`
List all users	`cut -d: -f1 /etc/passwd`

🔹 1. User and Group Management

🛠️ User Commands

Task	Command
Force password reset	`chage -d 0 alice`
Expire user	`usermod --expiredate 1 alice`
Lock user	`usermod -L alice`
Unlock user	`usermod -U alice`
Set shell	`usermod -s /bin/bash alice`

👥 Group Commands

Task	Command
Add group	`groupadd devs`
Delete group	`groupdel devs`
Rename group	`groupmod -n devops devs`
Add user to group	`usermod -aG devs alice`
Remove user from group	`gpasswd -d alice devs`
View user groups	`groups alice`
List all groups	`cut -d: -f1 /etc/group`
View group members	`getent group devs`

🔹 2. Profiles and Shell Environments

A **profile** defines a user's environment on login: shell, environment variables, aliases, etc.

📂 User Shell Files

File	Purpose
`~/.bashrc`	Run for interactive shells
`~/.profile`	Run for login shells
`~/.bash_logout`	Run at logout
`/etc/profile`	System-wide login configuration
`/etc/bash.bashrc`	System-wide interactive shell

⚙ Common Customizations

- Define variables:

```
export PATH=$PATH:/opt/tools
export EDITOR=nano
```

- Add aliases:

```
alias ll='ls -lah'
alias gs='git status'
```

- Customize prompt (`PS1`), umask, etc.

Reload with:

```
source ~/.bashrc
```

🔹 3. Hardening Identity Security

🔐 Enforce Password Policies

Install module:

```
sudo apt install libpam-pwquality
```

Edit `/etc/security/pwquality.conf`:

```
minlen = 12
dcredit = -1
ucredit = -1
ocredit = -1
lcredit = -1
```

Password aging:

```
chage -M 90 alice      # Max days
chage -m 7 alice       # Min days
chage -W 10 alice      # Warning before expiry
chage -l alice         # List settings
```

🔒 Account Restrictions

Task	Command
Lock user	`passwd -l alice` or `usermod -L alice`
Unlock user	`passwd -u alice`
Expire now	`chage -E 0 alice`
Disable shell access	`usermod -s /usr/sbin/nologin alice`

🔐 Sudo Configuration

Edit via `visudo`:
Allow full access:

```
alice ALL=(ALL) ALL
```

Restrict to command:

```
bob ALL=(ALL) NOPASSWD: /usr/bin/systemctl restart nginx
```

📋 Monitor Login & Auth Activity

- View successful logins:

```
last
```

- View failed logins:

```
faillog -a
```

- Check logs:

```
less /var/log/auth.log
journalctl -u ssh
```

🧱 Home Directory Permissions

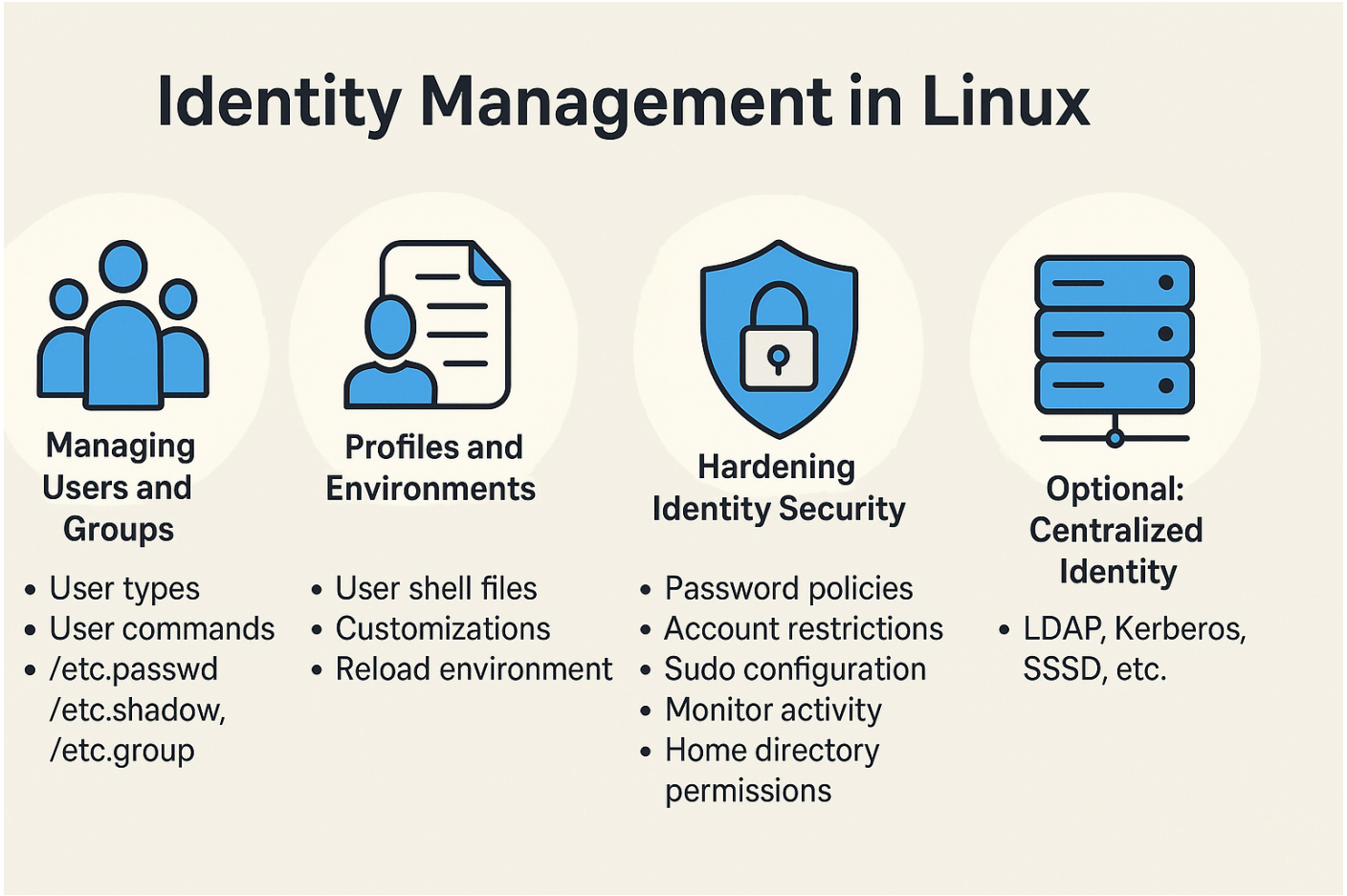
Protect user home:

```
chmod 700 /home/alice
chown alice:alice /home/alice
```

Use `umask` (e.g. `027`) to restrict default file permissions:

```
# Add to /etc/profile or ~/.profile
umask 027
```

Identity Management



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Package Management

1. Introduction to Package Management Systems

In Linux, a **package** is a bundle that contains:

- A **program** (binaries and libraries)
- **Metadata** (name, version, architecture, description)
- **Dependencies** (other packages required)
- Sometimes **scripts** (pre-install/post-install hooks)

This allows us to **install, update, or remove** software in a clean, reproducible, and automated way.

🛠️ What is a Package Manager?

A **package manager** is a tool that automates:

- Searching for software
- Installing software
- Upgrading or downgrading packages
- Handling dependencies
- Verifying versions and integrity

🧩 Example:

When you type `sudo apt install firefox`, the system:

1. Downloads the `firefox` package.
2. Resolves and downloads all dependencies.
3. Installs it.
4. Updates internal records (logs, index).

🔹 2. Installing, Updating, and Resolving Package Conflicts

🧰 What does `apt update` do?

This doesn't upgrade software. It **updates the list** of available packages from online sources (repositories).

```
sudo apt update
```

Without it, your system might not know if updates are available.

🔄 `apt upgrade` vs `full-upgrade`

- `apt upgrade`: Upgrades installed packages **without removing any existing ones**.
- `apt full-upgrade`: Can **remove or replace packages** if necessary (use with caution).

🧩 Dependency Conflicts

Sometimes, two packages require different versions of the same library — this creates a **conflict**.
🛠️ Example:

```
sudo dpkg -i package.deb
```

You might get:

```
dependency error: libXYZ (>= 2.0) not found
```

To fix:

```
sudo apt install -f
```

This asks APT to **fix** broken dependencies.

🔹 3. Managing DEB, RPM, AppImage, Flatpak, Snap

🧱 DEB – Debian Package Format

- Used by: Debian, Ubuntu, Linux Mint
- Managed by: `apt` or `dpkg`

🧠 **APT** handles everything automatically (dependencies, upgrades).
🧠 **DPKG** is lower-level. You use it to **install a `.deb` file manually**.
🛠️ Example:

```
sudo dpkg -i mypackage.deb
sudo apt install -f  # to fix dependencies if needed
```

📄 Summary:

- `.deb` is efficient for stable distros
- Community has created massive repos (e.g., Ubuntu Universe)

📦 RPM – Red Hat Package Manager

- Used by: Red Hat, Fedora, CentOS, AlmaLinux
- Managed by: `dnf`, `yum`, and `rpm`

🧠 **DNF/YUM** = handles dependencies
🧠 **RPM** = installs manually, doesn't resolve dependencies
🛠️ Example:

```
sudo dnf install nginx
# or manually:
sudo rpm -ivh mypackage.rpm
```

📄 Summary:

- Very powerful, but historically more manual than APT
- Supports GPG signing, rollback, group installs

💡 AppImage – Portable App

- Think of it as a **standalone executable**.
- You **don't install it**, you **run it directly**.

🛠️ Steps:

```
chmod +x AppImageName
./AppImageName
```

📄 Summary:

- No root access needed
- Ideal for testing or carrying apps on USB
- Doesn't integrate well with system package managers

📦 Flatpak – Universal Sandboxed App

- Cross-distro package format.
- Runs in a sandboxed environment.
- Each app includes **its own runtime**, isolated from the system.

🧠 You install a **runtime** (shared libraries) + the app itself.
🛠️ Example:

```
flatpak install flathub org.gimp.GIMP
flatpak run org.gimp.GIMP
```

📄 Summary:

- Ideal for desktop GUI apps
- Uses **Flathub** as its default repository

📦 Snap – Ubuntu's Self-Contained Package System

- Developed by Canonical (Ubuntu).
- Each Snap contains all dependencies.
- Runs in a container-like environment.

🛠️ Example:

```
sudo snap install vlc
snap list
```

📄 Summary:

- Popular in Ubuntu, slower startup time
- Easy auto-updates
- Does not depend on host distro

🔹 4. Installing Applications from Tarball Archives

A **tarball** is just a compressed archive:

- It can contain **binaries**, **source code**, or **portable versions** of software.
- `.tar.gz`, `.tgz`, `.tar.xz` are common formats.

🛠️ Example:

```
wget http://example.com/myapp.tar.gz
tar -xzf myapp.tar.gz
cd myapp
```

You might find a:

- `bin/` directory with an executable → Run directly
- `README.md` or `INSTALL` with manual instructions

📄 Summary:

- No automatic updates or dependency handling
- You manage everything manually

5. Compiling and Installing from Source

This is the **most advanced method**. You do it when:

- You need a specific version
- You want to enable/disable certain features
- You want to optimize for your hardware

🧱 Step-by-step: Compiling from Source

1. Install the build tools:

```
sudo apt install build-essential
# Or on RHEL-based:
sudo dnf groupinstall "Development Tools"
```

2. Download the source code:

```
wget https://example.org/tool.tar.gz
tar -xzf tool.tar.gz
cd tool
```

🧱 Step-by-step: Compiling from Source

3. Configure the build:

```
./configure --prefix=/usr/local
```

This prepares the Makefiles and checks for dependencies.

4. Compile:

```
make
```

5. Install:

```
sudo make install
```

🔁 Optional cleanup:

```
make clean
```

✅ Conclusion

Format	Ideal For	Package Manager	Automatic Updates
DEB	Ubuntu/Debian servers	APT	✅
RPM	RHEL/CentOS/Fedora	DNF/YUM	✅
AppImage	Portable, no root	none	❌
Flatpak	Sandboxed GUI apps	Flatpak	✅
Snap	Ubuntu desktop/server	Snap	✅
Tarball	Custom builds	Manual	❌
Source	Advanced/Custom config	Manual	❌

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DISK AND FILE SYSTEM MANAGEMENT

🔹 1. Overview of File System Types: `ext2`, `ext3`, `ext4`

A **file system** is a set of rules and data structures that control how data is stored and retrieved on a disk. It decides:

- How files and directories are organized
- How metadata (owner, date, permissions) is stored
- How data integrity is ensured

📚 EXT Family: `ext2`, `ext3`, `ext4`

File System	Journaling	Max File Size	Performance	Reliability	Best Use Case
ext2	❌ No	~2 TB	Fastest	Unsafe if crash	USB sticks, read-only partitions
ext3	✅ Yes	~2 TB	Moderate	Good	Legacy systems needing journaling
ext4	✅ Yes	~16 TB	Best	Excellent	Default in modern Linux distros

- **ext4** supports extents (faster, less fragmentation), delayed allocation (performance), and large volumes.
- **ext2** is ideal for USB drives because it doesn't write extra journal data — reducing write cycles.
- **ext3** was the default before ext4; you may still see it in production systems.

🛠️ Demo: Formatting Partitions

```
# Format as ext2
sudo mkfs.ext2 /dev/sdb1

# Format as ext3
sudo mkfs.ext3 /dev/sdb1

# Format as ext4
sudo mkfs.ext4 /dev/sdb1
```

🔹 2. Partitioning and Logical Volume Management (LVM)

Partitioning divides a disk into logical sections. Each can have:

- A specific mount point (`/`, `/home`, `/var`)
- A different file system (`ext4`, `xfs`)
- Different roles (boot, swap, data)

🧠 Partition Table Types

- **MBR** (Legacy, max 2 TB, 4 primary partitions)
- **GPT** (Modern, required for UEFI, supports > 2 TB and many partitions)

3. Formatting and Mounting File Systems

Formatting prepares a device (partition or volume) by creating its internal file system structure (superblock, inodes, journal, etc.).

```
sudo mkfs.ext4 /dev/sdb1
```

Mounting attaches a file system to a directory (mount point), so that the OS can access its contents.

```
sudo mkdir /mnt/data
sudo mount /dev/sdb1 /mnt/data
```

🧠 fstab and Permanent Mounting

The `/etc/fstab` file defines which partitions should be mounted automatically at boot.
Example entry:

```
UUID=b63f-44de /mnt/data ext4 defaults 0 2
```

To find the UUID of a device:

```
sudo blkid
```

To mount all defined in `fstab`:

```
sudo mount -a
```

🔹 4. Configuring Quotas for Users and Groups

A **quota** is a limit on disk usage for a **user** or **group** on a mounted file system.
You can limit:

- Disk space (blocks)
- Number of files (inodes)

🎯 Use Cases

- Prevent a single user from filling up the server
- Control storage usage in a shared environment
- Enforce fair usage among students or tenants

🧠 Required conditions

- The file system must be mounted with `usrquota` and/or `grpquota`
- Quotas must be initialized using `quotacheck`

🛠️ Step-by-Step Setup

```
# 1. Enable quotas in fstab (ext4 only)
sudo nano /etc/fstab
/dev/sda1 /home ext4 defaults,usrquota,grpquota 0 2

# 2. Remount the filesystem
sudo mount -o remount /home

# 3. Create quota files and enable
sudo quotacheck -cug /home
sudo quotaon /home

# 4. Set quota for user alice
sudo edquota alice
```

🛠️ Step-by-Step Setup

This opens an editor:

```
Disk quotas for user alice:
/dev/sda1: blocks in use: 5000, soft limit: 8000, hard limit: 10000
```

To check quotas:

```
quota -u alice
```

✅ What is LVM (Logical Volume Manager)?

LVM is a storage layer **between physical disks and the file system**. It allows:

- Resizing partitions on the fly
- Snapshots for backup/testing
- Combining multiple physical disks into a single volume group

🎯 Why use LVM?

- You can extend `/home` without unmounting.
- You can move logical volumes between disks.
- You can easily create a backup snapshot before risky updates.

🧠 LVM Concepts

Layer	Command	Description
Physical Volume (PV)	`pvcreate`	Raw disk or partition
Volume Group (VG)	`vgcreate`	Pool of PVs
Logical Volume (LV)	`lvcreate`	Virtual partition from VG

🛠️ Demo: Create a Logical Volume

```
# Step 1: Create two partitions (e.g., /dev/sdb1 and /dev/sdc1)
sudo pvcreate /dev/sdb1 /dev/sdc1

# Step 2: Create volume group
sudo vgcreate vgdata /dev/sdb1 /dev/sdc1

# Step 3: Create a logical volume
sudo lvcreate -L 5G -n lvbackups vgdata

# Step 4: Format it and mount
sudo mkfs.ext4 /dev/vgdata/lvbackups
sudo mkdir /mnt/backups
sudo mount /dev/vgdata/lvbackups /mnt/backups
```

🔹 5. Introduction to RAID

RAID stands for **Redundant Array of Independent Disks**. It's used to:

- Increase **reliability** (mirroring, parity)
- Improve **performance** (striping)
- Create **large volumes** from small disks

🧠 Software vs. Hardware RAID

- **Hardware RAID**: managed by a physical RAID controller
- **Software RAID**: configured by the OS (e.g., `mdadm` in Linux)

🎯 RAID Level Summary

RAID	Minimum Disks	Redundancy	Performance	Use Case
0	2	❌ None	✅ Fast	Scratch disks, temp data
1	2	✅ Mirror	Read: ✅	System disks, important data
5	3	✅ Parity	Balanced	NAS, backup
10	4	✅ Mirror+Stripe	✅✅ Fast + Safe	Databases

🛠️ Create RAID 1 with `mdadm`

```
# Install tool
sudo apt install mdadm

# Create a RAID 1 mirror
sudo mdadm --create /dev/md0 --level=1 --raid-devices=2 /dev/sdb /dev/sdc

# Format and mount
sudo mkfs.ext4 /dev/md0
sudo mount /dev/md0 /mnt/raidmirror

# View status
cat /proc/mdstat
```

Save config:

```
sudo mdadm --detail --scan >> /etc/mdadm/mdadm.conf
```

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File and Access Management

🔹 1. Standard Permissions: SUID, SGID, Sticky Bit

Linux uses 3 permission categories:

- **User (u)** → the owner of the file
- **Group (g)** → users in the same group
- **Others (o)** → everyone else

Each can have **read (r)**, **write (w)**, and **execute (x)** permissions.

✅ What is SUID (Set User ID)?

SUID tells the system: **run this file with the permissions of the file's owner** (usually root), no matter who executes it.

🧠 Use case:

- The `passwd` command lets regular users change their passwords, but needs root to edit `/etc/shadow`.

1. Standard Permissions: SUID, SGID, Sticky Bit

```
# Create a test script
sudo cp /usr/bin/passwd /tmp/passwdcopy
sudo chmod u+s /tmp/passwdcopy
ls -l /tmp/passwdcopy
```

Expected output:

```
-rwsr-xr-x 1 root root ... /tmp/passwdcopy
```

Note the `s` in place of the owner's `x`.

🔹 1. Standard Permissions: SUID, SGID, Sticky Bit

✅ What is SGID (Set Group ID)?

SGID on files:

- The process runs with the group ownership of the file.

SGID on directories:

- **All new files and subdirectories inherit the directory's group**, instead of the user's primary group.

🧠 Use case:

- Shared development folders where all files must belong to group `devteam`.

🔹 1. Standard Permissions: SUID, SGID, Sticky Bit

```
sudo mkdir /srv/dev
sudo chgrp devteam /srv/dev
sudo chmod 2775 /srv/dev
```

Now any file created in `/srv/dev` will belong to group `devteam`.

✅ What is the Sticky Bit?

Sticky bit on directories allows:

- **Only the file's owner (or root) to delete it**, even if others have write access.

🧠 Use case:

- Public shared folders like `/tmp`, where users can write but not delete each other's files.

1. Standard Permissions: SUID, SGID, Sticky Bit

```
sudo mkdir /srv/public
sudo chmod 1777 /srv/public
```

Check with:

```
ls -ld /srv/public
```

Output:

```
drwxrwxrwt 2 root root 4096 ... /srv/public
```

Note the final `t` (sticky bit).

🔹 2. Configuring Access Control Lists (ACLs)

ACLs allow you to define **multiple permissions** per file or directory, for **specific users and groups**, beyond standard owner/group/other.
Standard permissions only allow:

- One owner
- One group

ACLs allow:

- Custom rules for users like `bob: read-only`, `alice: full access`.

🛠️ Enable ACLs

Most modern Linux systems already support ACLs. To be sure:

1. The file system must be mounted with `acl` option (check `/etc/fstab`).
2. Install tools:

```
sudo apt install acl  # Debian/Ubuntu
sudo dnf install acl  # RHEL/Fedora
```

🛠️ Basic ACL Usage

```
# Set full access for alice
sudo setfacl -m u:alice:rwx /srv/data.txt

# Set read-only access for bob
sudo setfacl -m u:bob:r-- /srv/data.txt

# Set default ACL for a directory (inherit)
sudo setfacl -d -m u:alice:rwX /srv/shared

# View current ACLs
getfacl /srv/data.txt

# Remove ACL for bob
sudo setfacl -x u:bob /srv/data.txt

# Remove all ACLs
sudo setfacl -b /srv/data.txt
```

🧪 Example Test:

```
# Step 1: Create a test file as root
sudo touch /srv/test.txt

# Step 2: Set permission to 600 (owner only)
sudo chmod 600 /srv/test.txt

# Step 3: Add read permission for bob
sudo setfacl -m u:bob:r-- /srv/test.txt

# Step 4: Switch to bob and try to read
sudo -u bob cat /srv/test.txt
```

If ACL is correctly set, bob will be able to read even though he is not the owner.

🔹 3. Setting Up Collaborative Directories

A shared folder where **multiple users can create/edit files**, with **group-based access control** and possibly **ACL inheritance**.

🧠 Use case:

In a software development team:

- Files in `/srv/dev` should always belong to the group `devteam`
- Only team members can write
- Files should inherit correct permissions and group

🛠️ Setup Step-by-Step

```
# Create directory and group
sudo groupadd devteam
sudo mkdir /srv/dev

# Set group and permissions
sudo chgrp devteam /srv/dev
sudo chmod 2770 /srv/dev        # SGID bit ensures group inheritance

# Add users to devteam
sudo usermod -aG devteam alice
sudo usermod -aG devteam bob

# Optional: Set ACL defaults
sudo setfacl -d -m g:devteam:rwx /srv/dev
```

🧪 Test it:

```
# Switch to alice (in devteam)
sudo -u alice touch /srv/dev/test1

# Switch to bob and check if he can edit
sudo -u bob echo "hello" > /srv/dev/test1
```

You should see that:

- File is owned by `alice:devteam`
- Bob can write because he's in the same group and permissions are inherited

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DAEMON AND SERVICE MANAGEMENT

1. Understanding the Boot Process and Creating a Custom GRUB Configuration

GRUB2 (GRand Unified Bootloader version 2) is the program that loads your operating system **after the BIOS/UEFI finishes initializing hardware**.
It:

- Finds and loads the kernel (`vmlinuz`)
- Loads the initial RAM disk (`initrd` or `initramfs`)
- Passes parameters (like single user mode or runlevels)
- **Configuration files**:
  - `/etc/default/grub`: main settings (timeout, default OS, kernel parameters)
  - `/etc/grub.d/`: scripts used to build the boot menu
  - `/boot/grub/grub.cfg`: final bootloader configuration (auto-generated!)

1. Understanding the Boot Process and Creating a Custom GRUB Configuration

1. **Edit default config**:

```
sudo nano /etc/default/grub
```

Important variables:

```
GRUB_DEFAULT=0                          # First menu entry
GRUB_TIMEOUT=5                          # Seconds before boot
GRUB_CMDLINE_LINUX_DEFAULT="quiet splash"   # Kernel options (ex: `init=/bin/bash`)
```

2. **Generate updated configuration**:

```
# Debian/Ubuntu
sudo update-grub

# RHEL/Fedora
sudo grub2-mkconfig -o /boot/grub2/grub.cfg
```

🔹 1. Understanding the Boot Process and Creating a Custom GRUB Configuration

🧪 Example: Add a custom GRUB menu entry

```
sudo nano /etc/grub.d/40_custom
```

Add this entry:

```
menuentry "Rescue Shell" {
    set root=(hd0,1)
    linux /vmlinuz root=/dev/sda1 ro init=/bin/bash
    initrd /initrd.img
}
```

Then regenerate:

```
sudo update-grub
```

Use this entry at boot to launch into a shell without full init.

🔹 2. How `systemd` Works – Units, Services, and Targets

systemd is the init system and service manager for most modern Linux distributions. It replaces:

- SysVinit (`/etc/init.d/`)
- Upstart (Ubuntu before 15.04)

It manages:

- Services (`*.service`)
- Mount points (`*.mount`)
- Devices (`*.device`)
- Boot targets (`*.target`)
- Timers, sockets, etc.

🧠 Key Concepts

Unit Type	Description	Example
`.service`	Start, stop, restart processes	`apache2.service`
`.target`	Group of units (like runlevel)	`multi-user.target`
`.timer`	Schedule tasks (cron alternative)	`logrotate.timer`
`.socket`	Activates services on socket event	`cups.socket`

3. Creating and Managing Services with `systemd`

1. **Create your script**:

```
sudo nano /usr/local/bin/myservice.sh
```

```
#!/bin/bash
echo "$(date): Service started" >> /var/log/myservice.log
```

2. **Make it executable**:

```
sudo chmod +x /usr/local/bin/myservice.sh
```

3. **Create the service file**:

```
sudo nano /etc/systemd/system/myservice.service
```

3. Creating and Managing Services with `systemd`

```
[Unit]
Description=My Custom Logging Service
After=network.target

[Service]
ExecStart=/usr/local/bin/myservice.sh
Type=oneshot

[Install]
WantedBy=multi-user.target
```

4. **Enable and start it**:

```
sudo systemctl daemon-reexec     # Reload binary
sudo systemctl daemon-reload     # Reload unit files
sudo systemctl enable myservice
sudo systemctl start myservice
```

🔹 4. Creating Custom Targets in `systemd`

A **target** is a logical group of systemd units (like a runlevel). You can:

- Start a target (set of services)
- Make it default
- Create your own for specific use cases

🛠️ Create a Custom Target

1. **Create the target unit**:

```
sudo nano /etc/systemd/system/maintenance.target
```

```
[Unit]
Description=Maintenance Target
Requires=myservice.service
```

4. Creating Custom Targets in `systemd`

2. **Enable the target**:

```
sudo systemctl daemon-reload
sudo systemctl isolate maintenance.target
```

3. **Make it default (optional)**:

```
sudo systemctl set-default maintenance.target
```

To revert:

```
sudo systemctl set-default graphical.target
```

🔹 5. Managing SysVinit Services

Legacy software or old systems still use **SysVinit scripts** in `/etc/init.d`.
You can still manage them with `systemctl`, thanks to compatibility layers.

🛠️ Examples

```
# Start legacy service
sudo /etc/init.d/ssh start

# Or use systemctl
sudo systemctl start ssh

# Enable SysV service at boot
sudo update-rc.d ssh enable     # Debian
sudo chkconfig ssh on           # RHEL
```

Check if you have `/etc/init.d/service` scripts:

```
ls /etc/init.d/
```

🔹 6. Rescue and Emergency Modes – Real Use

✅ What are they?

Mode	Description
`rescue.target`	Minimal environment, with root shell and basic services
`emergency.target`	Only root shell, no services, no mounts

🎯 Why use them?

- Fix corrupted `/etc/fstab`
- Reset forgotten root password
- Disable a faulty service causing boot failure

🛠️ Access these modes:

Option 1: From GRUB

1. At boot, press `e` on your GRUB entry
2. Find the `linux` line and add:

```
systemd.unit=rescue.target
```

or:

```
systemd.unit=emergency.target
```

3. Press `F10` or `Ctrl+X` to boot

**Option 2: From a running system

**

```
sudo systemctl isolate rescue.target
sudo systemctl isolate emergency.target
```

To return:

```
sudo systemctl default
```

🧪 Example: Recover from broken `/etc/fstab`

1. Add fake line:

```
echo "/dev/fake /mnt/fake ext4 defaults 0 2" | sudo tee -a /etc/fstab
```

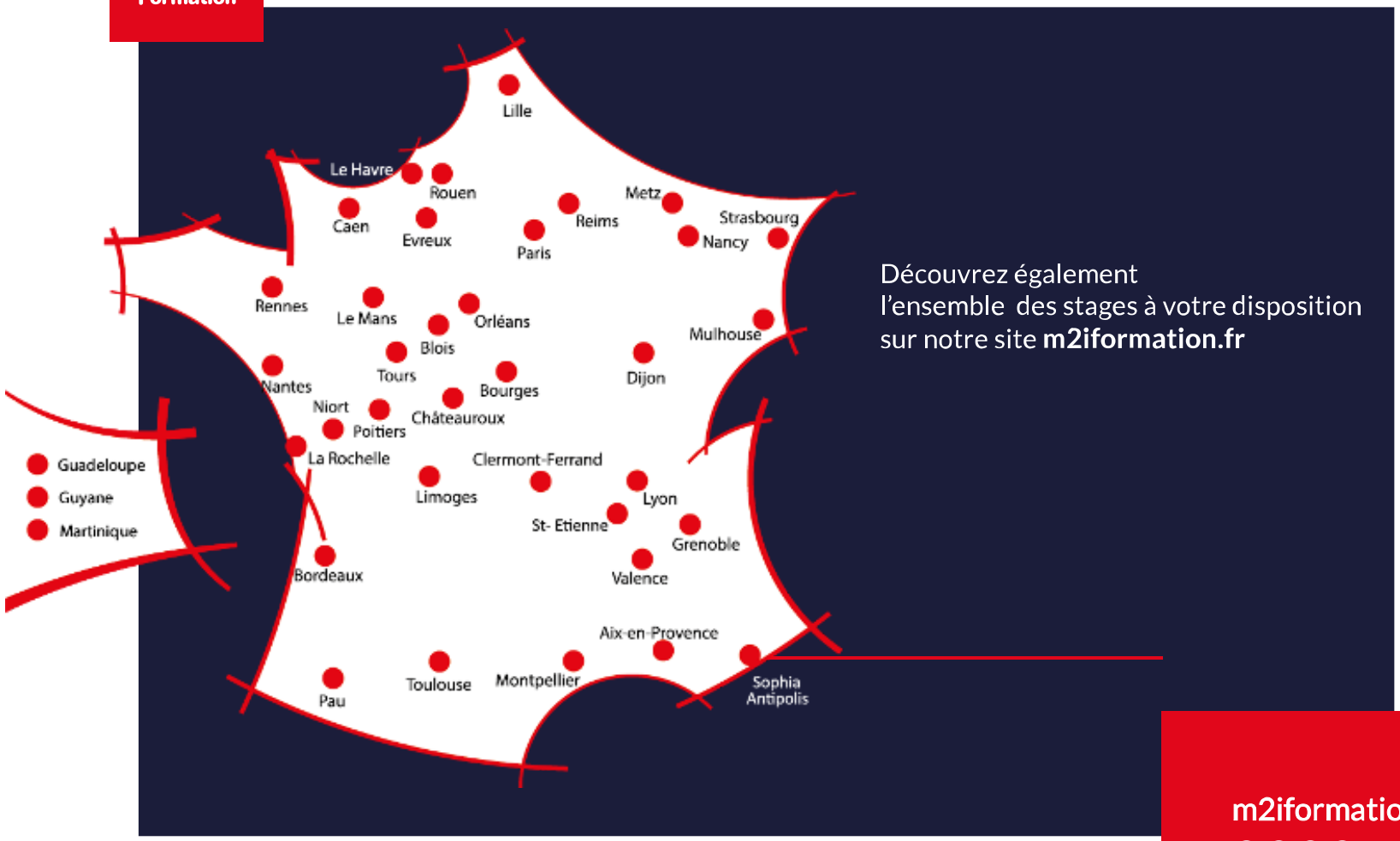
2. Reboot → system hangs
3. At GRUB, enter:

```
systemd.unit=emergency.target
```

4. Remount root:

```
mount -o remount,rw /
nano /etc/fstab
```

5. Fix the line, save, and reboot.



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