LINUX

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What is Linux?

- **Linux** is an **Operating System (OS)** — like Windows or macOS.
- But unlike them, **Linux is open-source**, meaning it's free and its code is publicly available.
- Linux is **used in servers, cloud computing, mobile (Android), embedded systems**, and DevOps tools.

Basic Components of Linux OS

Component	Explanation
Kernel	The core part of Linux that talks to hardware (like CPU, RAM, disks).
Shell	A program that lets you interact with the OS via commands.
File System	Organizes and stores data. Everything in Linux is treated as a **file** (even devices).
GUI	Optional — Linux can have graphical interfaces like GNOME or KDE, but often used via terminal.

Linux Directory Structure

Linux starts with **root (/) directory**. Below it, there are folders with fixed purposes:

Directory	Purpose
/	Root of the file system
/home	User folders (like C:\Users)
/bin	Essential command binaries (like ls, cp, mv)
/etc	System config files
/var	Variable files (like logs)
/tmp	Temporary files
/usr	User programs and libraries
/root	Home directory of the root (admin) user
/dev	Device files (like USB, hard disks)
/proc	System and process info (virtual folder)

Basic Linux Commands

Command	Use
pwd	Show current directory
ls	List files and folders
cd	Change directory
mkdir	Make a directory
touch	Create an empty file
cp	Copy files/folders

mv	Move or rename files
rm	Delete files
cat	Show file contents
clear	Clear the terminal
exit	Close the terminal or shell

User and Permissions

Linux is **multi-user**. Every file and folder has **permissions** and **ownership**.

Users:

- root: Superuser (admin)
- Normal users: Limited access

Permissions:

- Each file has 3 types of permissions for:
  - **Owner**
  - **Group**
  - **Others**

Permission types:

- r → read
- w → write
- x → execute

Example:
-rwxr-xr-- 1 user group 1234 Jul 1 file.sh
Breakdown:

- -rwxr-xr--
  - rwx (owner): full permission
  - r-x (group): read & execute
  - r-- (others): read only

Package Management (Installing Software)

- **Ubuntu/Debian-based**:
  - apt-get install <package-name>
- **Red Hat/CentOS**:
  - yum install <package-name> or dnf install
- **Others**: May use pacman, zypper, snap, flatpak

Processes and System Monitoring

Command	Description
ps	Show running processes
top	Live view of system usage (CPU, memory)
kill	Stop a process
htop	Better version of top (if installed)

File Compression and Archiving

Command	Description

tar -cvf	Create archive
tar -xvf	Extract archive
gzip, gunzip	Compress and decompress files

🔑 Important Concepts

Concept	Meaning
Shell Script	A file with commands you can execute like a program (.sh)
Cron Job	Schedule a task to run automatically
Log files	Located in /var/log, useful for troubleshooting
SSH	Remote login to a Linux machine (ssh user@ip)
Sudo	Temporarily run commands as root user (sudo <command>)

⚙️ How It Helps in DevOps

Linux is the **foundation** of:

- **Cloud servers** (AWS EC2, GCP, Azure)
- **CI/CD pipelines**
- **Docker & Kubernetes**
- **Automation tools like Ansible, Terraform**

🟩 What Are CRUD Operations?

CRUD stands for:

- **C** – Create
- **R** – Read
- **U** – Update
- **D** – Delete

In **Linux**, CRUD operations can be performed on:

- **Files**
- **Directories**
- **File content**
- **System records (like user data or processes)**

🟩 C – CREATE Operations in Linux

➤ Create a File

touch filename.txt
Example:
touch notes.txt

➤ Create a File with Content

echo "Hello, Linux!" > hello.txt
OR
cat > data.txt
Type your content
Press Ctrl+D to save

➤ Create a Directory (Folder)

mkdir foldername

Example:
mkdir projects

➤ Create Nested Directories
mkdir -p devops/scripts/yaml

▧ R – READ Operations in Linux

➤ View File Content
cat filename.txt
less filename.txt # Scrollable
more filename.txt # Page-wise output

➤ View First or Last Lines
head filename.txt # First 10 lines
tail filename.txt # Last 10 lines

➤ Read a Directory
ls # List files
ls -l # Detailed view
ls -a # Show hidden files

➤ Read a Specific Line (Using sed or awk)
sed -n '3p' filename.txt # Show 3rd line
awk 'NR==3' filename.txt # Another method

▨ U – UPDATE Operations in Linux

➤ Append to File
echo "New line" >> file.txt

➤ Edit File (Using Editors)
- nano filename.txt – beginner-friendly terminal editor
- vim filename.txt – powerful but advanced editor

➤ Replace Text in File
sed -i 's/oldtext/newtext/g' filename.txt
Example:
sed -i 's/Devops/Linux DevOps/g' notes.txt

➤ Rename File or Folder
mv oldname.txt newname.txt

➤ Move File to Different Location
mv file.txt /home/user/docs/

▧ D – DELETE Operations in Linux

➤ Delete a File
rm filename.txt

➤ Delete a Directory
rm -r foldername

➤ Force Delete
rm -rf foldername

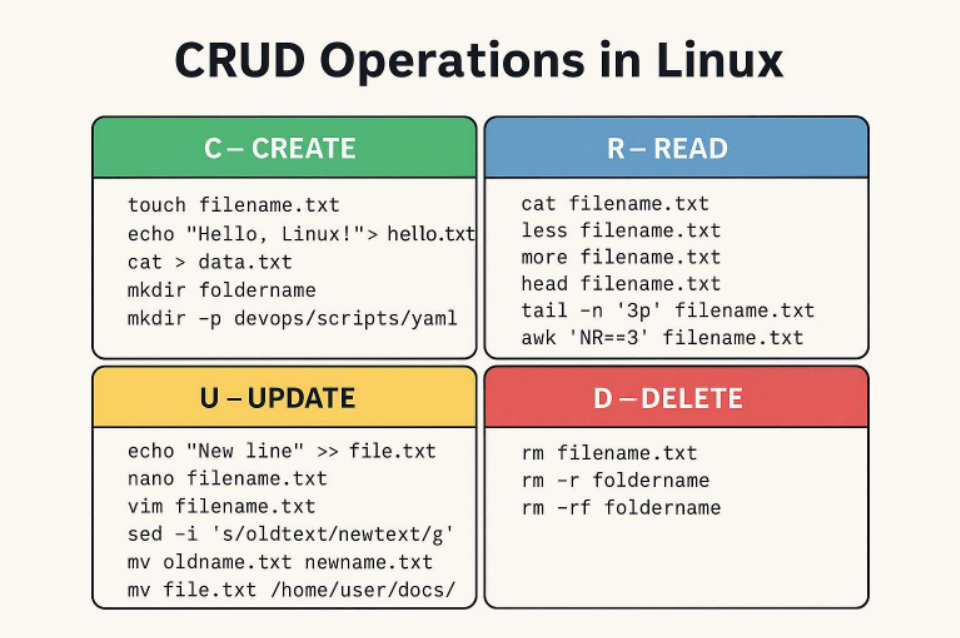
⚠ Be careful with rm -rf / — it can wipe out the entire OS.

🛠 Bonus: Real-Time DevOps Use Cases of CRUD in Linux

Task	Linux Command
Create a config file	touch nginx.conf
Read server logs	less /var/log/syslog
Update YAML for deployment	nano deployment.yaml
Delete temporary files	rm -rf /tmp/*
Move backup	mv backup.tar.gz /mnt/backup/

🧪 Sample Exercise to Practice

```
# Step 1: Create a directory and file
mkdir devops_practice
cd devops_practice
touch inventory.txt
# Step 2: Add data
echo "Server1: 192.168.1.1" >> inventory.txt
echo "Server2: 192.168.1.2" >> inventory.txt
# Step 3: Read and edit
cat inventory.txt
sed -i 's/192.168.1.2/10.0.0.2/' inventory.txt
# Step 4: Delete the file
rm inventory.txt
```



🧠 VIM Editor in Linux — Complete Notes with Modes & Editing Operations

◇ What is Vim?

- **Vim (Vi IMproved)** is a **modal text editor** in Linux.
- Used for editing **config files**, **shell scripts**, **YAML**, **Docker**, **Terraform**, and more — especially in **headless servers** and **DevOps** workflows.
- Runs in the terminal and is **lightweight**, **powerful**, and **scriptable**.

🎮 Vim Has 3 Primary Modes

Mode Name	Purpose	Enter Mode	Exit Mode
1. Normal Mode	Default mode — for navigation, deleting, copying	Open Vim or press Esc	Press i, v, or :
2. Insert Mode	Typing text (like in Notepad)	Press i, I, a, A, o, O	Press Esc
3. Command-Line Mode	Save, exit, search, run commands	Press : from Normal Mode	Press Enter or Esc

🔘 1. NORMAL MODE – The Control Hub

☑ Actions in Normal Mode:

Action	Key
Move cursor	h (left), l (right), j (down), k (up)
Word jump	w (next word), b (previous word)
Start of line	0
End of line	$
Top of file	gg
Bottom of file	G
Delete line	dd
Copy (yank) line	yy
Paste	p
Undo	u
Redo	Ctrl + r

🔘 2. INSERT MODE – For Writing or Editing Text

☑ Enter Insert Mode:

Key	Function
i	Insert before cursor
I	Insert at start of line
a	Insert after cursor
A	Insert at end of line
o	Open a new line below
O	Open a new line above

Once in insert mode, you type normally like any text editor.

☑ Exit Insert Mode:

- Press Esc to go back to **Normal Mode**.

3. COMMAND-LINE MODE – For Save, Quit, Search

☑ Enter Command Mode:

- From Normal Mode, press : (colon)

☑ Common Commands:

Command	Meaning
:w	Save file
:q	Quit
:wq or ZZ	Save and quit
:q!	Force quit without saving
:x	Save and exit (if changes made)
:set nu	Show line numbers
:set nonu	Hide line numbers

Editing Operations in Vim (DevOps Oriented)

File & Config Editing:

vim /etc/nginx/nginx.conf

1. Navigate to the line using arrow keys or j/k.
2. Press i to enter insert mode.
3. Make changes.
4. Press Esc, then type :wq to save and exit.

Searching and Replacing

- **Search for a word**:
  /nginx

  Then press n (next match) or N (previous match)
- **Replace all occurrences in file**:
  :%s/oldtext/newtext/g

Copy, Cut, Paste (Yank, Delete, Put)

Action	Key
Copy (line)	yy
Copy (3 lines)	3yy
Delete (cut) line	dd
Delete 5 lines	5dd
Paste below	p
Paste above	P

Line and Block Editing

- **Visual Mode** (v): Select characters/words
- **Visual Line Mode** (V): Select entire lines
- **Visual Block Mode** (Ctrl + v): Select columns

Then you can press y, d, or p to copy, cut, or paste.

Practical DevOps Examples

Task	Vim Command
Edit crontab	crontab -e (uses Vim by default)
Change pod name in YAML	vim pod.yaml, /name, i, edit
Format Terraform code	vim main.tf, use =G to auto-indent
Edit Dockerfile	vim Dockerfile
Restart NGINX config	Edit nginx.conf then sudo systemctl restart nginx

Sample Practice

vim test.sh

1. Press i, type:
   #!/bin/bash
   echo "Hello, Vim World!"
2. Press Esc
3. Save: :wq
4. Make executable: chmod +x test.sh
5. Run it: ./test.sh

Vim Cheat Sheet Summary

Mode	Enter	Purpose	Exit
Normal	Open Vim / Esc	Navigation, editing	i, :, v
Insert	i, a, o, etc.	Typing text	Esc
Command	:	Save, quit, search	Enter or Esc

Linux File & Directory Permissions – Full Guide

Why Permissions Matter?

- Linux is a **multi-user OS**, and permissions **protect files, scripts, and system settings** from unauthorized access or modification.
- Common in **DevOps, cloud environments, and CI/CD pipelines** where secure access is critical.

Permission Types

Each file or directory in Linux has **3 types of permissions** for **3 types of users**:

User Categories:

Symbol	User Type

u	User (Owner)
g	Group
o	Others (Everyone else)

🔤 Permission Types:

Symbol	Permission	Meaning
r	Read	View content
w	Write	Modify content
x	Execute	Run file (scripts, binaries) or enter directory

📄 Example Output from ls -l

-rwxr-xr-- 1 devops team 2048 Jul 1 deploy.sh

Breakdown:

Part	Meaning
-	File type (- = file, d = directory)
rwx	Owner: read, write, execute
r-x	Group: read, execute
r--	Others: read only
devops	Owner username
team	Group name

🔢 Numeric (Octal) Permissions

Each permission has a numeric value:

Permission	Binary	Octal
r	100	4
w	010	2
x	001	1

Add values to get final permission:

rwx combo	Value
rwx	7
rw-	6
r--	4
r-x	5

So:
chmod 755 filename
= rwxr-xr-x

🔧 chmod – Change Permissions

◇ Symbolic Method:

```
chmod u+x script.sh      # Add execute to user
chmod g-w file.txt       # Remove write from group
```

chmod o=r file.txt # Others: read-only

◇ Numeric (Octal) Method:

chmod 644 file.txt # rw-r--r--
chmod 755 script.sh # rwxr-xr-x
chmod 700 secrets.txt # rwx------ (only owner can access)

chown – Change Ownership

chown user:group file
Example:
chown devops:team deploy.sh

Permissions for Directories

Permission	Effect
r	Can list files (ls)
w	Can add/remove files
x	Can enter directory (cd)

Example:
drwxr-x--- 2 riyas team 4096 Jul 1 logs/

- Owner: full access
- Group: can read and enter
- Others: no access

Special Permissions

Symbol	Name	Use
s	**Setuid / Setgid**	Run program with owner/group privileges
t	**Sticky Bit**	Used in /tmp so only file owner can delete their files

Example:

chmod +t /shared/folder
ls -ld /shared/folder
drwxrwxrwt → sticky bit set

DevOps Use Cases

Task	Related Permission
Make shell script executable	chmod +x script.sh
Restrict .env to user only	chmod 600 .env
Secure private keys	chmod 400 key.pem
Allow group to deploy	chown :deployers deploy.sh
Lock config file	chmod 444 config.yml (read-only)

Summary Table

Octal	Symbolic	Meaning

777	rwxrwxrwx	Everyone full access
755	rwxr-xr-x	Owner full, others can read/execute
700	rwx------	Only owner access
644	rw-r--r--	Read/write owner, read others
600	rw-------	Only owner can read/write

🧪 Practice Exercise

```
# Create a file
touch test.sh
# Give only the owner full access
chmod 700 test.sh
# Make it executable
chmod +x test.sh
# Change ownership to "devops" user and "ci" group
chown devops:ci test.sh
# Set read-only for everyone
chmod 444 test.sh
```

👤 Linux User Management – Full Guide

🔑 Why Is User Management Important?

In a multi-user system (like Linux servers or cloud environments), **managing users, groups, and permissions** ensures:

- Security & isolation
- Controlled access to files/scripts/services
- Auditing and accountability

📇 1. Understanding Users & Groups

👤 Types of Users

User Type	Description
Root	Superuser with all permissions
System Users	Created by services (e.g., nginx, mysql)
Regular Users	Created by admins for login and tasks

👥 Groups

- Groups are collections of users.
- Users can belong to **multiple groups**.
- Groups simplify permission management (e.g., give access to a folder for all devops users).

🔧 2. Create, Delete, and Manage Users

➕ Create User

```
sudo adduser riyas
```

- Adds user with home directory: /home/riyas
- Prompts to set password

OR basic (less interactive):
sudo useradd -m riyas
sudo passwd riyas

➖ Delete User

sudo deluser riyas # Keeps home dir
sudo deluser --remove-home riyas
Or:
sudo userdel -r riyas

🛠️ Modify User

sudo usermod -aG devops riyas # Add to 'devops' group
sudo usermod -l newname oldname # Rename user
sudo usermod -d /new/home/path riyas # Change home dir

📝 3. User Info and Files

📂 Key Files

File	Purpose
/etc/passwd	User account info (username, UID, GID, shell)
/etc/shadow	Encrypted passwords
/etc/group	Group definitions
/etc/sudoers	Who can use sudo

🔍 View User Info

cat /etc/passwd | grep riyas
id riyas # Show UID, GID, groups
groups riyas # Show group memberships

👥 4. Group Management

➕ Create Group

sudo groupadd devops

➕ Add User to Group

sudo usermod -aG devops riyas

➖ Remove User from Group (manually):

sudo gpasswd -d riyas devops

➖ Delete Group

sudo groupdel devops

🔐 5. Sudo (Superuser Do) Access

Grant Sudo Access to a User

sudo usermod -aG sudo riyas
OR edit sudoers file safely:
sudo visudo
Then add:

riyas ALL=(ALL:ALL) ALL

🔐 Limited Sudo (for security):

Only allow specific commands:
riyas ALL=(ALL) NOPASSWD: /bin/systemctl restart nginx

📁 6. Home Directory & Shell

Task	Command
View home	echo $HOME
Change default shell	chsh -s /bin/bash riyas
Set home manually	usermod -d /custom/home riyas

🔐 7. Lock and Unlock Users

🚫 Lock Account

sudo usermod -L riyas

🔓 Unlock Account

sudo usermod -U riyas

🔐 Disable Login Shell (block login)

sudo usermod -s /usr/sbin/nologin riyas

🧪 8. Real DevOps Use Cases

Task	Command
Create a user for Jenkins agent	adduser jenkins_agent
Restrict a user to deploy only	usermod -aG docker deployer
Setup SSH-only user	Create user, disable password, set up SSH key
Group-level permission for /var/www	Create webdev group, set directory group ownership
Give NGINX team restart permission only	sudo visudo + command restriction
SFTP-only access	Create chrooted SFTP users with nologin shell

📊 Cheat Sheet Summary

Task	Command
Add user	adduser <name>
Delete user	deluser <name> or userdel -r
Add to group	usermod -aG <group> <user>
List groups	groups <user>
Create group	groupadd <group>
Lock account	usermod -L <user>
Give sudo access	usermod -aG sudo <user>

Linux Process Management – Detailed Guide

What Is a Process?

A **process** is any **program or command** that is running on your Linux system.
It has a unique **PID (Process ID)** and can be **running, sleeping, stopped**, or **zombie**.

Process States

State	Meaning
R	Running
S	Sleeping (idle but waiting)
T	Stopped
Z	Zombie (terminated but not cleaned up)
D	Uninterruptible sleep (I/O wait)

1. View Running Processes

List All Processes

ps -ef

- Shows user, PID, parent PID (PPID), time, and command

Real-Time Monitoring

top

- Interactive, live view of CPU, memory, and processes

htop

- Better version of top (requires installation):

```
sudo apt install htop   # Debian/Ubuntu
sudo yum install htop   # RHEL/CentOS
```

2. Search for a Specific Process

```
ps aux | grep nginx
pgrep nginx      # Show PID(s) of nginx
```

3. Understand Process Hierarchy

pstree

- Visualizes parent-child process structure

4. Start a Process

./script.sh

Run in Background

./script.sh &

Keep Running After Logout (Use nohup)

nohup ./script.sh &

5. Kill/Stop/Manage a Process

Action	Command
Kill by PID	kill <PID>
Force kill	kill -9 <PID>
Kill by name	pkill nginx
Kill all matching	killall nginx

Example:
kill -9 1243
pkill -f python

🚦 6. Foreground vs Background Jobs

🏁 Run in Foreground

./longtask.sh

➕ Move to Background

- Press Ctrl + Z → pauses task
- Run bg → resumes in background

📋 View Jobs

jobs

🔙 Bring Back to Foreground

fg %1

🔐 7. Set Priority (nice, renice)

📉 Launch with Low Priority

nice -n 10 ./task.sh

📈 Change Priority of Running Process

renice -n 5 -p 1234

- Lower value = higher priority
- -20 (highest), 19 (lowest)

🧠 8. Process Details & Memory/CPU Stats

📊 Check Memory Usage

ps aux --sort=-%mem | head

📈 Check CPU Usage

ps aux --sort=-%cpu | head

👨‍💻 9. DevOps Use Cases

Task	Command
Restart Jenkins if not running	`pgrep jenkins
Monitor Docker CPU usage	top, htop, or docker stats
Check stuck process during deploy	`ps aux
Kill zombie Python script	kill -9 $(pgrep -f script.py)
Auto-restart failed process	Use supervisord or systemd

10. Advanced Tools

Tool	Use
strace	Trace system calls of a process
lsof	List files used by processes
watch	Re-run a command repeatedly
systemctl	Manage background services (systemd)
cron	Schedule recurring tasks (not real-time process management but related)

Summary Table

Command	Purpose
ps -ef	List all processes
top / htop	Live process monitor
kill, pkill, killall	Stop processes
jobs, fg, bg	Manage background/foreground jobs
nice, renice	Adjust process priority
pgrep, pstree	Search or view hierarchy
lsof, strace	Debug processes/files

Practice Scenario

```
# 1. Create a test script
echo -e "#!/bin/bash\nsleep 300" > sleeper.sh
chmod +x sleeper.sh
# 2. Run it in background
./sleeper.sh &
# 3. View process
ps -ef | grep sleeper
# 4. Kill it
kill -9 <PID>
```

Linux Package Management – Complete Guide

What Is Package Management?

- **Packages** are compressed files that contain programs, libraries, or tools.
- **Package managers** are tools to **install, update, remove, or search** for software on Linux.
- DevOps often relies on package management to automate infrastructure setup (e.g., installing Docker, Ansible, or monitoring tools).

Types of Linux Package Managers

Linux distros use different package managers:

Distro Family	Tool	File Extension
Debian/Ubuntu	apt, dpkg	.deb
RHEL/CentOS/Fedora	yum, dnf, rpm	.rpm
Arch Linux	pacman	.pkg.tar.zst
Universal	snap, flatpak, AppImage	—

APT (Advanced Packaging Tool) – Ubuntu/Debian

Common Commands

Task	Command
Update list of packages	sudo apt update
Upgrade all packages	sudo apt upgrade
Install package	sudo apt install nginx
Remove package	sudo apt remove nginx
Search package	apt search <name>
Get info	apt show <package>
Clean old packages	sudo apt autoremove

Install from .deb File

```
sudo dpkg -i file.deb
sudo apt -f install   # Fix missing dependencies
```

YUM/DNF – RHEL, CentOS, Fedora

DNF is the newer replacement for YUM.

Common Commands

Task	YUM	DNF
Install	sudo yum install nginx	sudo dnf install nginx
Remove	sudo yum remove nginx	sudo dnf remove nginx
Update system	sudo yum update	sudo dnf upgrade
Search	yum search nginx	dnf search nginx

Install from .rpm

```
sudo rpm -ivh package.rpm
```

Use yum localinstall package.rpm to auto-resolve dependencies.

pacman – Arch Linux & Derivatives

```
sudo pacman -Syu          # Full system update
sudo pacman -S package-name  # Install
sudo pacman -R package-name  # Remove
sudo pacman -Ss search-term  # Search
```

snap – Universal Package Manager

- Works across distros.

- Packages include all dependencies (like containers).
- Slower but very easy to use.

```
sudo snap install code --classic
sudo snap remove code
snap list
```

flatpak – Alternative Universal Manager

```
flatpak install flathub com.spotify.Client
flatpak run com.spotify.Client
```

DevOps Use Cases

Task	Command
Install Docker on Ubuntu	sudo apt install docker.io
Install Git on CentOS	sudo yum install git
Setup Prometheus via RPM	sudo rpm -ivh prometheus.rpm
Install Terraform via .deb	sudo dpkg -i terraform_1.7.deb
Automate installs in shell scripts	Include apt, yum, or snap commands
Use Ansible to manage packages	apt: name=nginx state=present

Bonus Tools

Tool	Use
dpkg	Low-level Debian tool (for .deb)
rpm	Low-level Red Hat tool (for .rpm)
aptitude	TUI for apt package management
brew	Popular on macOS and Linux (Homebrew)
conda/pip	Python packages (for ML/dev tasks)

Sample Practice Task (Ubuntu)

```
# 1. Update and install
sudo apt update
sudo apt install htop
# 2. Check installed version
htop --version
# 3. Remove it
sudo apt remove htop
```

Summary Table

Action	APT	YUM/DNF	RPM	Snap
Install	apt install	yum install	rpm -ivh	snap install
Remove	apt remove	yum remove	rpm -e	snap remove
Update system	apt upgrade	yum update	—	—
List installed	dpkg -l	yum list installed	rpm -qa	snap list

🛠 Linux Service Management – Complete Guide (Init + Systemd)

🚦 What is a Service?

- A **service** (also called a daemon) is a background process, like:
  - nginx, docker, sshd, mysql, etc.
- Services start:
  - **Manually** (on demand)
  - **Automatically** (at boot)
- In Linux, services are **managed using init systems**:
  - Older: SysVinit (commands: service, chkconfig)
  - Modern: systemd (commands: systemctl, journalctl)

⚙ 1. systemctl – Modern Service Manager (systemd-based)

Most modern Linux distributions (Ubuntu ≥15, CentOS 7+, Debian ≥8, RHEL 7+) use **systemd**.

☑ Common systemctl Commands

Task	Command
Start a service	sudo systemctl start nginx
Stop a service	sudo systemctl stop nginx
Restart a service	sudo systemctl restart nginx
Reload without restart	sudo systemctl reload nginx
Check status	systemctl status nginx

🔁 2. Enable/Disable at Boot

Action	Command
Enable auto-start	sudo systemctl enable nginx
Disable auto-start	sudo systemctl disable nginx
Check if enabled	systemctl is-enabled nginx

📜 3. View Service Logs

journalctl -u nginx

Option	Description
-u	Show logs for specific service
-f	Follow logs (like tail -f)
--since "10 min ago"	Filter by time

Example:
journalctl -u docker -f

🗂 4. Service Files and Paths (systemd)

Location	Purpose
/etc/systemd/system/	Custom service unit files
/lib/systemd/system/	Default service unit files
*.service files	Define how to start/stop a service

5. Anatomy of a .service File

Example: /etc/systemd/system/myapp.service

```
[Unit]
Description=My Flask App
After=network.target
[Service]
ExecStart=/usr/bin/python3 /opt/myapp/app.py
WorkingDirectory=/opt/myapp
Restart=always
User=ubuntu
[Install]
WantedBy=multi-user.target
```

Enable and Start It:

```
sudo systemctl daemon-reload
sudo systemctl enable myapp
sudo systemctl start myapp
```

6. Legacy Commands (SysVinit-based distros)

If your system uses **SysVinit** (e.g., CentOS 6):

Task	Command
Start	sudo service nginx start
Stop	sudo service nginx stop
Restart	sudo service nginx restart
Enable at boot	chkconfig nginx on
Disable	chkconfig nginx off

7. DevOps Real-World Use Cases

Scenario	Command
Restart Jenkins after update	systemctl restart jenkins
Enable Docker at boot	systemctl enable docker
Check failed services	systemctl --failed
View service logs after crash	journalctl -xe
Set up custom monitoring service	Write .service file + enable it
Auto-restart failed app	Add Restart=always in .service file

Summary: systemctl Cheat Sheet

Command	Use

systemctl start <service>	Start service now
systemctl stop <service>	Stop it
systemctl restart <service>	Restart it
systemctl status <service>	Show status
systemctl enable <service>	Start on boot
systemctl disable <service>	Don’t start on boot
journalctl -u <service>	View logs
systemctl daemon-reexec	Reload systemd itself

🗀 Best Practices (DevOps)

- Use systemctl over service on modern distros.
- For scripts, check service status before acting:
  ```
  if systemctl is-active --quiet nginx; then
     echo "Nginx is running"
  fi
  ```
- Set **Restart policies** in .service files for resilience.
- Always daemon-reload after editing service files.

🌐 Linux Network Management – Complete Guide

📌 Why Network Management Matters

In Linux-based systems (servers, containers, VMs), network management helps to:

- Configure **IP addresses**, DNS, routing
- Check connectivity and **troubleshoot issues**
- Manage **firewalls**, ports, and **network services**
- Set up virtual networks (important in **Docker/Kubernetes**)

🧰 1. Essential Networking Commands

◇ Check IP Address & Interfaces

```
ip addr show          # Modern
ifconfig              # Legacy (requires `net-tools`)
hostname -I           # Show IP only
```

◇ View Routing Table

```
ip route show
route -n
```

◇ Check DNS Info

```
cat /etc/resolv.conf
```

◇ View/Change Hostname

```
hostname              # Show hostname
hostnamectl set-hostname newname
```

📡 2. Connectivity & Troubleshooting Tools

Tool	Use
ping <host>	Check if host is reachable
traceroute <host>	Show path to host
nslookup <host>	DNS resolution
dig <host>	Advanced DNS info
telnet <host> <port>	Test port connectivity
nmap <host>	Scan open ports
netstat -tulnp	Show listening ports (TCP/UDP)
ss -tuln	Modern version of netstat
curl, wget	Test HTTP/HTTPS connections
tcpdump	Packet capture tool
ip a, ip r, ip link	Interface and routing config

3. Configure Network Interfaces

Using ip (Modern Tool)

Assign IP manually:
sudo ip addr add 192.168.1.10/24 dev eth0
sudo ip link set eth0 up
Remove IP:
sudo ip addr del 192.168.1.10/24 dev eth0

Using nmcli (NetworkManager CLI – GUI-Based Systems)

nmcli device status # Show devices
nmcli connection show # List connections
nmcli connection up "Wired connection 1" # Enable connection

4. Network Configuration Files

File	Purpose
/etc/hosts	Map hostnames to IPs manually
/etc/hostname	System's hostname
/etc/resolv.conf	DNS nameservers
/etc/network/interfaces	(Debian-based static IP config)
/etc/sysconfig/network-scripts/ifcfg-*	(RHEL-based network config)

5. Firewall Management

UFW (Ubuntu/Debian)

sudo ufw status
sudo ufw allow 22 # Allow SSH
sudo ufw deny 80
sudo ufw enable

Firewalld (RHEL/CentOS/Fedora)

sudo firewall-cmd --list-all

```
sudo firewall-cmd --add-port=8080/tcp --permanent
sudo firewall-cmd --reload
```

iptables (Legacy/Manual)

```
sudo iptables -L          # List rules
sudo iptables -A INPUT -p tcp --dport 22 -j ACCEPT
```

Many DevOps tools still use iptables rules underneath.

6. Host to Host Communication

Task	Command
Test SSH	ssh user@host
Share file	scp file.txt user@host:/path
Sync folders	rsync -av /source/ user@host:/target/
Setup port forwarding	ssh -L 8080:localhost:80 user@remote

7. DevOps Real-World Use Cases

Scenario	Tool/Command
Check server port before deploy	`ss -tuln
Validate DNS for API call	dig api.myapp.com
Configure static IP on cloud VM	/etc/netplan/*.yaml or nmcli
Expose container port to host	docker run -p 8080:80 nginx
Detect broken microservice	curl http://service:port/health
Monitor traffic	iftop, nethogs, tcpdump
Test firewall blocking	telnet host port or nmap host

Summary Table

Tool	Purpose
ip	Modern IP and route management
ss, netstat	View listening services
ping, traceroute	Network diagnostics
curl, wget	Test HTTP/HTTPS
dig, nslookup	DNS tools
nmap	Port scanner
iptables, ufw, firewalld	Firewalls
nmcli, nmtui	GUI/CLI network config

Practice Task

```
# Check IP and routes
ip a
ip route
# Ping gateway
```

```
ping 192.168.1.1
# Test DNS resolution
dig google.com
# Scan open ports
nmap localhost
# Check service listening
ss -tuln | grep 22
# Allow HTTP in firewall
sudo ufw allow 80
```

🛠 Linux Troubleshooting – Full Guide

📌 What Is Troubleshooting?

Troubleshooting in Linux means identifying and fixing:

- System errors
- Service failures
- Performance bottlenecks
- Network issues
- Disk problems
- Permissions and access issues

🔍 1. Basic Diagnostic Questions

Before diving into tools, ask:

- What exactly isn't working?
- When did it start?
- Has anything changed recently (updates, config, deployments)?
- Can it be replicated?
- Logs available?

🔍 2. System Health Check

➤ CPU, Memory, Load

```
top
htop
uptime          # Check load average
free -h         # Check memory usage
vmstat 1        # System performance in real-time
```

➤ Disk Usage

```
df -h           # Show available disk space
du -sh *        # Check size of subdirectories
lsblk           # List block devices
```

➤ Check Disk Errors

```
dmesg | grep -i error
sudo smartctl -a /dev/sda
```

🌐 3. Network Troubleshooting

Task	Command
Check IP address	ip a or ifconfig
Ping a host	ping 8.8.8.8 or ping google.com
Trace route	traceroute google.com
DNS check	dig, nslookup
Port test	telnet host port, nmap, or nc -zv host port
View open/listening ports	ss -tuln, netstat -tulnp
Restart network	systemctl restart NetworkManager or sudo service networking restart

4. Log Files (Goldmine of Info)

Location	Purpose
/var/log/syslog or /var/log/messages	General system logs
/var/log/auth.log	Login attempts, sudo access
/var/log/dmesg	Kernel and hardware logs
/var/log/nginx/ or /var/log/httpd/	Web server logs
/var/log/mysql/	DB logs
/var/log/journal/	systemd logs (if journald enabled)

View logs:

tail -n 50 /var/log/syslog
journalctl -xe

5. Service Failures (Systemd-based systems)

Check status and logs:

systemctl status nginx
journalctl -u nginx -b

Restart or reload:

sudo systemctl restart nginx
sudo systemctl daemon-reload

6. Permission Issues

Common symptoms:

- Permission denied errors
- Files not executable
- Services unable to read config files

Commands:

ls -l filename
chmod +x script.sh
chown user:group file
Check if service is running as correct user (e.g., nginx, www-data).

7. Application Debugging (e.g., Python, Bash, Node.js)

Tool	Use

bash -x script.sh	Debug bash scripts line by line
python3 -m pdb script.py	Python debugger
npm run dev or node app.js	Watch console logs for Node.js
curl -v	Verbose API call debugging

8. Database Troubleshooting

Action	Command
Check MySQL status	systemctl status mysql
Access MySQL	mysql -u root -p
View DB logs	/var/log/mysql/error.log
PostgreSQL logs	/var/log/postgresql/postgresql.log
Test DB connection	mysqladmin ping or psql -h host -U user

9. Package/Dependency Problems

- Debian/Ubuntu:
  sudo apt update
  sudo apt install -f
  sudo dpkg --configure -a
- RHEL/CentOS:
  sudo yum clean all
  sudo yum check

10. Process & Resource Issues

Task	Command
List processes	ps -ef, top, htop
Kill process	kill <PID> or pkill <name>
Zombie process check	`ps aux
Memory hogs	`ps aux --sort=-%mem
CPU hogs	`ps aux --sort=-%cpu

11. Reboot, Shutdown, Recovery

Task	Command
Reboot	sudo reboot
Shutdown	sudo shutdown now
Rescue Mode (grub)	Hold Shift at boot > Select **Advanced** > **Recovery mode**
Remount root fs	mount -o remount,rw /
Filesystem check	fsck /dev/sda1 (carefully, needs unmounted disk)

12. Troubleshooting Checklist

☑ Is the **service running**?

☑ Is the **port open** and listening?
☑ Can you **ping / curl** the target?
☑ Do you see anything in the **logs**?
☑ Is it a **permission** or **ownership** problem?
☑ Is the **disk or memory full**?
☑ Has **anything changed** (deployment, config, updates)?

Tools Worth Installing

Tool	Description
htop	Advanced resource monitor
iftop, nethogs	Live network usage
ncdu	Disk usage analyzer
strace	Trace system calls
lsof	List open files
tcpdump	Network packet capture

Sample Scenario to Practice

```
# Your service stopped working
systemctl status myapp.service        # Step 1: Check status
journalctl -u myapp -n 50             # Step 2: Check logs
ss -tuln | grep 8080                  # Step 3: Port listening?
df -h                                 # Step 4: Disk space?
ps -ef | grep myapp                   # Step 5: Process alive?
```

- Full **admin (sudo)** access
- **Partial (limited command)** access
- With clear **examples**, **commands**, and **explanations** for each step

Scenario Overview

Assume you're a DevOps/Linux admin and need to:

1. Add a new user
2. Give them:
    - Either **full sudo** (admin) access
    - Or **limited command** access (e.g., restart Apache only)

☑ Step-by-Step: Create and Manage Linux User Access

◇ Step 1: Create a New User

```
sudo adduser john
```

📌 This creates a new user john with a home directory.

◇ Step 2: Set a Password for the User

```
sudo passwd john
```

💡 Prompt will ask for and confirm a password.

◇ Step 3: Give Full Admin (sudo) Access

➤ **Option 1: Add to the sudo group (Debian/Ubuntu)**
sudo usermod -aG sudo john
➤ **Option 2: For CentOS/RHEL**
sudo usermod -aG wheel john
📌 This gives full root-equivalent access via sudo.
☑ **Test:**
Login as john and run:
sudo whoami
Expected output: root

🔒 PARTIAL / LIMITED ACCESS (For Security or Compliance)

◇ Step 4: Allow Specific Command via sudoers

Use the visudo command to safely edit the sudoers file:
sudo visudo
➞ Inside the file, add the below rule at the end:
john ALL=(ALL) NOPASSWD: /bin/systemctl restart apache2
🔍 Explanation:

- john: The username
- ALL=(ALL): Can run as any user
- NOPASSWD: Won't be prompted for password
- /bin/systemctl restart apache2: Only this command allowed with sudo

☑ **Test:**
Login as john, then run:
sudo /bin/systemctl restart apache2
Should work ☑
But:
sudo apt update
Will result in **permission denied** ✖

✳ BONUS: Allow Multiple Commands

john ALL=(ALL) NOPASSWD: /sbin/ifconfig, /usr/bin/apt-get update

🔍 How to Find Command Full Paths

Use:
which <command>
Example:
which systemctl

🔐 Restrict Shell Access (Optional)

To block shell login but allow cron/FTP:
sudo usermod -s /usr/sbin/nologin john

🔍 Check Group of a User

groups john

🔄 Remove a User's Sudo Access

Remove user from sudo group:
sudo deluser john sudo # Ubuntu/Debian
sudo gpasswd -d john wheel # RHEL/CentOS
Or remove entry from visudo.

📝 Summary Table

Task	Command
Add user	sudo adduser john
Set password	sudo passwd john
Full admin	sudo usermod -aG sudo john
Partial access	sudo visudo → add custom rule
Check access	sudo -l -U john
Remove sudo	sudo deluser john sudo

📌 Real-World Example Use Case (DevOps):

Use Case: Give DevOps intern only permission to restart Nginx and view logs

1. Create user:

sudo adduser devopsintern

1. Edit sudoers via visudo:

devopsintern ALL=(ALL) NOPASSWD: /bin/systemctl restart nginx, /usr/bin/tail -n 100 /var/log/nginx/error.log

☑ Now they can:
sudo /bin/systemctl restart nginx
sudo /usr/bin/tail -n 100 /var/log/nginx/error.log
But cannot do anything else with sudo.

🗂 Linux File System Structure – Detailed Notes

The **Linux file system** is a **hierarchical directory structure** that starts from the **root (/)** directory and branches out to other subdirectories.

🧱 1. Root Directory /

- The top-level directory of the Linux file system.
- All files and directories start from here.
- It is the **parent of all other directories**.

📁 2. Standard Directories Under /

Directory	Description
/bin	**Essential user binaries** (commands): ls, cp, mv, rm, etc.
/sbin	**System binaries**: Admin-level tools like iptables, reboot, ifconfig.

/boot	Contains **bootloader files**, Linux kernel (vmlinuz), initrd, GRUB config.
/dev	**Device files**: e.g., /dev/sda, /dev/tty0. Represents hardware devices as files.
/etc	**System-wide configuration files**: e.g., /etc/passwd, /etc/hosts, /etc/fstab.
/home	**User home directories**: /home/riyas, /home/mohan.
/lib	Essential **shared libraries** for binaries in /bin and /sbin.
/media	Mount point for **removable media**: USB, CD/DVD auto-mounted here.
/mnt	Used for **temporarily mounting file systems** manually by the user.
/opt	Optional application packages (e.g., third-party apps like Chrome, VMware).
/proc	Virtual filesystem providing **process and kernel info** (e.g., /proc/cpuinfo).
/root	**Home directory of root user**. Different from /home/root.
/run	Runtime data since the last boot, like PID files, socket files.
/srv	Service-related data for servers like FTP, WWW.
/sys	Virtual filesystem showing **kernel info about devices**.
/tmp	Temporary files. Cleared on reboot.
/usr	Secondary hierarchy for read-only user data; has subdirs like /usr/bin, /usr/lib.
/var	Variable data like **logs, spool files, cache, and emails**.

3. Important /etc Files and Their Use

File	Purpose
/etc/passwd	Stores user account information
/etc/shadow	Contains user password hashes
/etc/group	Stores group info
/etc/hostname	Sets system hostname
/etc/fstab	Contains auto-mount information
/etc/hosts	Maps IP addresses to hostnames
/etc/resolv.conf	DNS configuration
/etc/systemd/	Contains service files and system boot configuration

4. Important /var Subdirectories

Directory	Purpose
/var/log	System log files (important for troubleshooting)
/var/spool	Print and mail spools
/var/tmp	Temp files preserved between reboots
/var/cache	Cached data from applications
/var/www	Web files (for Apache/Nginx servers)

5. Virtual Filesystems: /proc, /sys, /dev

- **/proc**:
  - Dynamic, virtual filesystem.

    - Used to access **process info**, system uptime, memory stats.
    - Example: cat /proc/cpuinfo, cat /proc/meminfo.
- **/sys**:
    - Interfaces with **kernel devices**.
    - Helps in examining and interacting with hardware.
- **/dev**:
    - Represents **devices as files**.
    - Example: /dev/sda = hard disk, /dev/ttyUSB0 = USB device.

6. Package & Binary Locations

Path	Use
/bin	Essential system binaries
/usr/bin	Non-essential user commands
/sbin, /usr/sbin	Admin commands
/lib, /usr/lib	Shared libraries
/opt	Third-party packages

7. User & Permissions

- Each user has a **home directory** inside /home.
- The **root user's home** is /root.
- Use ls -l / to view permissions and ownership of top-level directories.

8. Mount Points

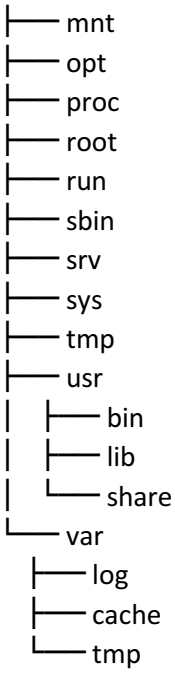
- Devices or partitions are attached to the Linux file system via **mount points**.
- Example:
    - mount /dev/sdb1 /mnt/usb
    - /mnt, /media, /run/media are common mount paths.

9. Key Concepts to Remember

- Everything in Linux is a **file** (including hardware and processes).
- The file system follows **FHS** (Filesystem Hierarchy Standard).
- Root (/) is the origin — all other directories are children of it.
- **Separation of concerns**: logs, binaries, configs, libraries — all have dedicated locations.

Diagram of Linux File System Hierarchy

```
/
├── bin
├── boot
├── dev
├── etc
├── home
│   ├── user1
│   └── user2
├── lib
├── media
```


mnt
opt
proc
root
run
sbin
srv
sys
tmp
usr
bin
lib
share
var
log
cache
tmp