Linux Notes

By

H.M. Ashis Rahman

Content

1. Linux Basics & Filesystem Structure

- What is Linux?
  - Kernel vs Operating System
  - Popular Distributions: Ubuntu, CentOS, Fedora, Debian, Arch
- Basic Commands:
  pwd, ls, cd, man, whoami, clear
- Filesystem Hierarchy:
  / - Root directory
  /home - User directories
  /etc - Configuration files
  /var - Variable data (logs, spool)
  /bin - Essential binaries
  /usr - User system resources
  /tmp - Temporary files
  /root - Root user's home
  /dev - Device files
  /proc - Kernel and process info

2. File Management

- Viewing Files:
  cat, less, more, head, tail
- File Operations:
  cp, mv, rm, touch, mkdir, rmdir
- Permissions:
  chmod (e.g. chmod 755 file)
  chown, chgrp
  Symbolic (u+x) vs Numeric (755, 644)
- Links:
  Hard links: ln source link
  Soft links: ln -s source link

3. Process Management

- Viewing Processes:
  ps, top, htop, jobs

- Managing Processes:
  kill, killall, nice, renice
- Foreground & Background:
  &, fg, bg, CTRL+Z
- Signals:
  kill -9 (SIGKILL), kill -15 (SIGTERM), trap

4. User & Group Management

- User Commands:
  adduser, useradd, passwd, usermod, deluser
- Group Commands:
  groupadd, groups, gpasswd
- Important Files:
  /etc/passwd, /etc/shadow, /etc/group
- Switching Users:
  su, sudo, whoami, id

5. Networking Commands

- Interface Management:
  ip a, ifconfig, ip link, ip route
- Network Tools:
  ping, traceroute, host, dig, nslookup
- File Transfers:
  scp, rsync, wget, curl
- Connections:
  netstat, ss, lsof -i

6. Package Management

- Debian-based:
  apt update, apt install, apt remove
  dpkg -i package.deb
- Red Hat-based:
  yum install, dnf remove, rpm -ivh package.rpm
- Common Tasks:
  Search, install, remove, upgrade, clean

7. File Search & Text Processing

- Search Commands:
  find, locate, which, whereis, type
- Grep & Regex:
  grep, egrep, fgrep
- Text Tools:
  cut, awk, sed, sort, uniq, tr, wc, xargs, tee

8. Shell Scripting Basics

- Script Structure:
  #!/bin/bash
  chmod +x script.sh
- Variables & Input:
  var=value, read var
- Conditionals:
  if, elif, else, case
- Loops:
  for, while, until
- Arguments:
  $0, $1, $#, $@, $?, $$

9. System Services & Logs

- systemd Commands:
  systemctl start|stop|enable|status service
  journalctl -xe
- Logs:
  /var/log/syslog, /var/log/auth.log, dmesg
  tail -f /var/log/file.log
- Scheduled Jobs:
  crontab -e
  Cron format: min hr dom mon dow
  at, anacron

10. Disk & System Information

- Disk Usage:
  df -h, du -sh, lsblk, fdisk -l
  mount, umount, blkid

- Filesystems:
  mkfs, fsck, tune2fs
- System Info:
  uname -a, uptime, free -h, top, vmstat
  lscpu, lsmem, hostnamectl

1. Linux Basics & Filesystem Structure

What is Linux?

- Linux is a free and open-source Unix-like operating system based on the Linux kernel.
- It is the core component of many operating systems known as "Linux distributions" (distros).
- The Linux kernel manages hardware, processes, memory, and system calls.
- Popular distributions include:
  - Ubuntu (Debian-based)
  - CentOS, RHEL, Fedora (Red Hat-based)
  - Arch Linux, Manjaro
  - Debian, Kali Linux

Basic Linux Commands

- pwd : Print the current working directory
- ls : List directory contents
  - ls -l : Long format
  - ls -a : Include hidden files
- cd : Change directory
  - cd .. : Go to parent directory
  - cd ~ : Go to home directory
- man : Show manual for a command (e.g. man ls)
- whoami : Print current user ID
- clear : Clear the terminal screen

Filesystem Hierarchy Standard (FHS)

- / : Root directory (top-level)
- /home : User home directories (/home/user)
- /root : Root user’s home directory
- /etc : Configuration files
- /bin : Essential user binaries (e.g. ls, cp)
- /sbin : System binaries (for root/admin)
- /usr : Secondary hierarchy (user software and libraries)
  - /usr/bin : Most user commands
- /var : Variable data (logs, mail, spool)
- /tmp : Temporary files

- /dev   : Device files (e.g. /dev/sda)
- /proc   : Kernel and process info (virtual filesystem)
- /mnt   : Temporary mount point
- /media : Removable media (USB, CD-ROM)

Tips

- Use `tab` for autocompletion in the terminal.
- Use `man` or `--help` to learn about any command.

2. File Management

Viewing File Contents

- cat filename   : View entire file content
- less filename   : Scroll through file (use q to quit)
- more filename   : View file page-by-page
- head filename   : Show first 10 lines (use -n for custom lines)
- tail filename   : Show last 10 lines (use -f to follow updates)

Creating and Modifying Files

- touch filename   : Create an empty file or update timestamp
- echo "text" > file : Write text to a file (overwrites)
- echo "text" >> file: Append text to a file

File and Directory Operations

- cp source dest   : Copy file
  - cp -r dir1 dir2 : Copy directories recursively
- mv source dest   : Move or rename files/directories
- rm filename   : Delete file
  - rm -r dir   : Delete directory recursively
  - rm -f file   : Force delete without prompt
- mkdir dirname   : Create a directory
- rmdir dirname   : Delete an empty directory

File Permissions and Ownership

- chmod [options] filename : Change file permissions
  - Symbolic mode: chmod u+x file (adds execute to user)
  - Numeric mode : chmod 755 file
    - 7 = rwx, 5 = r-x, 0 = ---
- chown user:group file : Change file owner
  - Example: chown root:root /etc/config
- chgrp group file : Change group ownership

Linking Files

- Hard Link: ln source linkname
  - Points to the same inode, file content persists if original is deleted
- Symbolic (Soft) Link: ln -s source linkname
  - Like a shortcut, breaks if source is deleted

Useful Flags and Tricks

- rm -i : Prompt before every deletion
- cp -i : Confirm before overwriting
- mv -i : Confirm before overwriting
- Use wildcards:
  - * : Matches any number of characters
  - ? : Matches a single character
  - [abc] : Matches any one of the characters a, b, or c

3. Process Management

Viewing Processes

- ps : Snapshot of current processes
  - ps aux : Show all processes with full details
  - ps -ef : Alternative full-format listing
- top : Dynamic real-time process monitor
- htop : Enhanced top (needs installation)
- jobs : List background jobs in current shell

Foreground and Background Processes

- command & : Run command in the background

- fg : Bring background job to foreground
- bg : Resume suspended job in background
- CTRL+Z : Suspend (pause) foreground job
- CTRL+C : Terminate (SIGINT) foreground job

Killing Processes

- kill PID : Send signal to a process
- killall name : Kill all processes with that name
- pkill name : Kill by process name (supports regex)
- xkill : Click on a window to force close it

Common Signals

- SIGTERM (15) : Terminate process gracefully
  - kill -15 PID
- SIGKILL (9) : Forcefully kill process (cannot be ignored)
  - kill -9 PID
- SIGINT (2) : Interrupt from keyboard (CTRL+C)
- SIGSTOP : Pause process (like CTRL+Z)
- SIGCONT : Continue a paused process

Nice and Renice

- nice -n [value] command : Run with specified priority (-20 to 19)
  - Lower value = higher priority
- renice -n [value] -p PID : Change priority of a running process

Process Information

- pgrep name : Get PID(s) of running processes
- pidof program : Get PID of a specific program
- pstree : Show process tree hierarchy

Useful Tricks

- Use `ps aux | grep program` to find running instances
- Combine `top` with filters or shortcuts (press `k` to kill in top)

4. User & Group Management

User Management

- adduser username : Add a new user (Debian-style, interactive)
- useradd username : Add a new user (low-level, non-interactive)
  - Options:
    - -m : Create home directory
    - -s /bin/bash : Set shell
- passwd username : Set or change user password
- deluser username : Delete a user (Debian-based)
- userdel username : Delete a user (may require -r to remove home)

Modifying Users

- usermod -aG group user : Add user to a group (append mode)
- usermod -s /bin/bash user : Change user shell
- usermod -L user : Lock user account
- usermod -U user : Unlock user account
- chage -l user : List password aging info

Group Management

- groupadd groupname : Create a new group
- groupdel groupname : Delete a group
- groups : Show groups of current user
- id : Show UID, GID, and groups
- gpasswd -a user group : Add user to group
- gpasswd -d user group : Remove user from group

Switching Users and Permissions

- su - username : Switch user (requires password)
- sudo command : Run command as root
- sudo -i : Open root shell
- whoami : Show current user
- id : Show user ID and group info

Important System Files

- /etc/passwd : User account info
- /etc/shadow : Encrypted passwords (root-readable)
- /etc/group : Group info
- /etc/sudoers : Sudo privileges (edit with visudo)

User & Group Identifiers

- UID (User ID) : Unique ID for each user
  - 0 = root
- GID (Group ID) : Unique ID for each group
- Files and processes are owned by UID and GID

Examples

- Create a user with home directory:
  useradd -m john
- Add user to 'sudo' group:
  usermod -aG sudo john
- Change user password:
  passwd john

5. Networking Commands

Checking Network Interfaces

- ip a : Show IP addresses and interfaces
- ifconfig : (Older tool) Show interface configuration
- ip link : Show link-level info (state, MAC)
- ip route : Show routing table
- hostname -I : Show IP addresses
- nmcli device status : Network Manager CLI (status of devices)

Testing Connectivity

- ping hostname/IP : Send ICMP packets to test connectivity
  - Example: ping google.com
- traceroute host : Show path taken by packets (install may be needed)
- mtr host : Real-time traceroute + ping (needs installation)

DNS Tools

- nslookup domain : Query DNS records
- dig domain : Detailed DNS query
- host domain : Basic DNS lookup
- /etc/resolv.conf : DNS resolver configuration file

Checking Open Ports and Services

- netstat -tuln : Show listening ports (TCP/UDP)
- ss -tuln : Modern replacement for netstat
- lsof -i : List open network connections
- ss -s : Summary of socket statistics

Downloading Files

- wget URL : Download files from the web
- curl -O URL : Download a file (use -L to follow redirects)
- scp source dest : Secure copy over SSH
  - Example: scp file.txt user@host:/path/
- rsync -avz src dst : Sync files/directories over SSH

Configuring Network (Manual)

- ip addr add 192.168.1.100/24 dev eth0
- ip route add default via 192.168.1.1
- ifdown eth0 && ifup eth0 (Debian-style)
- systemctl restart NetworkManager (or networking)

Hosts and Name Resolution

- /etc/hosts : Manual name-to-IP mappings
  - Format: 127.0.0.1 hostname
- /etc/hostname : System's hostname
- hostnamectl set-hostname newname

Common Network Services

- SSH: Secure shell (port 22)
  - Start: systemctl start ssh

  - Config: /etc/ssh/sshd_config
- HTTP: Web servers like Apache/Nginx (ports 80, 443)
- FTP, SMB, NFS: File sharing protocols

6. Package Management

Overview

- Linux distributions use package managers to install, update, and remove software.
- Package managers handle dependencies and install files to the correct locations.
- Different distros use different tools:
  - Debian/Ubuntu: apt, dpkg
  - Red Hat/CentOS/Fedora: yum, dnf, rpm
  - Arch Linux: pacman (not covered here)

Debian-based Systems (apt, dpkg)

- apt update : Update package list
- apt upgrade : Upgrade all installed packages
- apt install pkg : Install a package
- apt remove pkg : Remove a package
- apt purge pkg : Remove with config files
- apt autoremove : Remove unused packages
- apt search keyword : Search for packages
- apt show pkg : Show package info
- dpkg -i pkg.deb : Install .deb package manually
- dpkg -r pkg : Remove package
- dpkg -l : List installed packages

Red Hat-based Systems (yum, dnf, rpm)

- dnf install pkg : Install a package (yum works similarly)
- dnf remove pkg : Remove a package
- dnf update : Update all packages
- dnf upgrade : Upgrade packages (dnf only)
- dnf search keyword : Search for packages
- rpm -ivh pkg.rpm : Install .rpm manually
- rpm -e pkg : Remove .rpm package
- rpm -qa : List all installed packages

- rpm -ql pkg : List files installed by package

Repository Management

- /etc/apt/sources.list : Debian-based repo config
- /etc/yum.repos.d/ : Red Hat-based repo config
- Add external repos (e.g., PPA for Ubuntu):
  - add-apt-repository ppa:repo/name

Checking Package Info

- which command : Show path of an executable
- whereis command : Show location of command and man pages
- apt-cache show pkg : Show package metadata (Debian)
- dnf info pkg : Show package info (Red Hat)

Useful Tips

- Always run `apt update` or `dnf check-update` before installing new packages.
- Use `--no-install-recommends` with apt to avoid installing optional dependencies.
- Use `-y` with install/remove to skip confirmation prompts:
  - Example: apt install -y vim

7. File Search & Text Processing

File Search Commands

- find /path -name "filename" : Find files by name
  - Example: find /home -name "*.txt"
- find /path -type f -size +10M : Find files larger than 10MB
- find . -mtime -1 : Files modified in the last 1 day
- locate filename : Fast search (uses a database)
  - Requires updatedb to refresh DB
- which command : Show full path of a command
- whereis command : Locate binary, source, and man pages
- type command : Show how a command would be interpreted

Text Search (grep and variants)

- grep "pattern" file : Search for pattern in file
- grep -i "pattern" file : Case-insensitive search
- grep -r "pattern" dir/ : Recursive search in a directory
- grep -v "pattern" file : Exclude lines matching pattern
- grep -n "pattern" file : Show line numbers
- egrep, fgrep : Variants (egrep supports extended regex)

Text Processing Tools

- cut -d':' -f1 /etc/passwd : Extract 1st field using ':' as delimiter
- awk '{print $1, $3}' file : Print 1st and 3rd columns
  - awk -F':' '{print $1}' file : Use ':' as field separator
- sed 's/old/new/g' file : Replace text in file (non-destructive)
- tr 'a-z' 'A-Z' : Translate lowercase to uppercase
- sort file : Sort lines alphabetically
  - sort -n : Numerical sort
- uniq : Remove duplicate lines (often used after sort)
- wc file : Word/line/byte count
  - wc -l : Line count
- head -n 5 file : Show first 5 lines
- tail -n 10 file : Show last 10 lines
- xargs : Build and execute commands from stdin
  - Example: find . -name "*.log" | xargs rm

Combining Tools

- cat file | grep "error" | wc -l : Count error lines in file
- find . -name "*.sh" | xargs chmod +x : Make all .sh files executable

Redirection & Pipes

- command > file : Redirect output to file (overwrite)
- command >> file : Append output to file
- command < file : Use file as input
- command1 | command2 : Pipe output of one command to another
- tee file : Output to file and stdout

8. Shell Scripting Basics

Script Structure

- Shebang line: #!/bin/bash
  Specifies the interpreter to run the script
- Make script executable: chmod +x script.sh
- Run script: ./script.sh or bash script.sh

Variables
- Assign: var="value"
- Access: $var or ${var}
- Read user input: read varname
- Environment variables: PATH, HOME, USER, etc.

Arguments to Scripts
- $0   : Script name
- $1, $2, ... : Positional parameters (arguments)
- $#   : Number of arguments
- $@   : All arguments as separate words
- $*   : All arguments as a single string
- $?   : Exit status of last command
- $$: Process ID of the script

Basic Control Structures

1. Conditionals (if-else)
```
if [ condition ]; then
  commands
elif [ condition ]; then
  commands
else
  commands
fi
```

- Note: Use spaces inside [ ]
- Common tests:
  - -f file   : file exists and is a regular file
  - -d dir   : directory exists
  - -z str   : string is empty
  - str1 = str2 : string equality
  - num1 -eq num2 : numeric equality

2. Case Statement

```
case "$var" in
  pattern1)
    commands ;;
  pattern2)
    commands ;;
  *)
    commands ;;
esac
```

3. Loops
- for loop:
```
  for var in list; do
    commands
  done
```
- while loop:
```
  while [ condition ]; do
    commands
  done
```
- until loop:
```
  until [ condition ]; do
    commands
  done
```

Functions
- Define function:
```
  function_name () {
    commands
  }
```
- Call function:
```
  function_name
```

Exit Status
- 0 means success, non-zero means failure
- Use exit 0 or exit 1 to set script status

Comments
- Use # for single-line comments

Example Script
```
#!/bin/bash
```

```
echo "Enter your name:"
read name
if [ -z "$name" ]; then
  echo "No name entered"
else
  echo "Hello, $name!"
fi
```

9. System Services & Logs

Systemd and Service Management

- systemctl start service : Start a service immediately
- systemctl stop service : Stop a service immediately
- systemctl restart service : Restart a service
- systemctl reload service : Reload configuration without restarting
- systemctl enable service : Enable service to start at boot
- systemctl disable service : Disable service at boot
- systemctl status service : Show current status of a service
- systemctl list-units --type=service : List all active services

SysVinit (older systems)

- service service_name start : Start a service
- service service_name stop : Stop a service
- service service_name restart : Restart a service
- chkconfig service_name on/off : Enable/disable service at boot

Viewing Logs

- journalctl : Show systemd journal logs
  - journalctl -u service : Show logs for a specific service
  - journalctl -f : Follow logs in real-time
  - journalctl --since "2 hours ago"
- /var/log/syslog or /var/log/messages : Traditional log files
- dmesg : Kernel ring buffer messages
- tail -f /var/log/file.log : Follow log file changes

Log Rotation

- Logs can grow large; logrotate manages rotating, compressing logs
- Configuration file: /etc/logrotate.conf and /etc/logrotate.d/

Common Log Files

- /var/log/auth.log : Authentication logs
- /var/log/kern.log : Kernel messages
- /var/log/dpkg.log : Package manager logs (Debian)
- /var/log/yum.log : Package manager logs (Red Hat)
- /var/log/syslog : General system logs
- /var/log/messages : General messages and errors

Troubleshooting Tips

- Use systemctl status service to check if a service is active or failed
- Check journalctl or log files for detailed error messages
- Use dmesg for hardware or driver issues

Enabling and Checking Services at Boot

- systemctl is-enabled service : Check if a service is enabled at boot
- systemctl list-unit-files : List all services and their enablement status

10. Useful Tips & Commands

General Tips

- Use tab completion to speed up typing commands and file names.
- Use history command or ↑/↓ arrow keys to navigate command history.
- Use Ctrl + C to stop a running command.
- Use Ctrl + Z to pause a command and put it in the background.
- Use fg to bring a background job to the foreground.
- Use man command to read manual pages: man ls

File Permissions Recap

- Permission format: rwxrwxrwx (user-group-others)
- Change permissions:
  - chmod 755 file : Owner rwx, group and others rx
  - chmod u+x file : Add execute permission for owner

- Change ownership:
  - chown user file
  - chown user:group file

Disk Usage

- df -h : Show disk space usage by filesystem
- du -sh /path : Show size of directory or file

Process Management

- ps aux : List all running processes
- top : Interactive process viewer
- htop : Improved top (may require installation)
- kill PID : Send SIGTERM to process
- kill -9 PID : Force kill process
- pkill processname : Kill processes by name

Searching Files & Text

- locate filename : Fast filename search
- find /path -name "file" : Find files by name
- grep "pattern" file : Search text inside files

Networking Quick Commands

- ping host : Check connectivity
- traceroute host : Trace path packets take
- netstat -tuln : Show listening ports
- ssh user@host : Connect to remote host via SSH

Package Management Reminders

- Always update package lists before installing: apt update or dnf check-update
- Remove unnecessary packages with apt autoremove or yum autoremove

Shortcuts & Aliases

- Use alias to create shortcuts: alias ll='ls -alF'
- Add aliases to ~/.bashrc or ~/.bash_aliases for persistence

Help & Documentation

- man command : Read manual pages
- command --help : Show help for commands
- info command : GNU info pages