Linux: System Administration

TEKsystems Global Services

WORKFORCE DEVELOPMENT

LOGISTICS

Class Hours:

- Instructor will set class start and end times.
- There will be regular breaks in class.

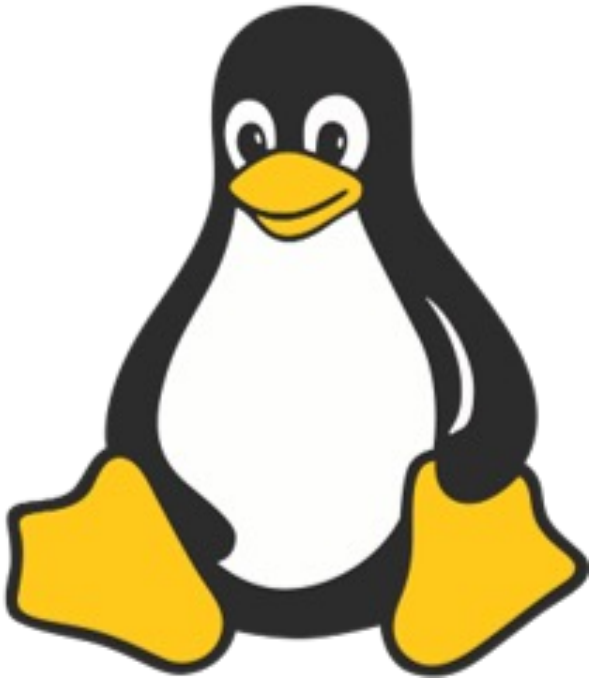
Telecommunication:

- **Turn off or set electronic devices to silent (not vibrate)**
- **Reading or attending to devices can be distracting to other students**
- **Try to delay until breaks or after class**

Miscellaneous:

- Courseware
- Bathroom
- Fire drills

Course Objectives



- By the end of this course, you will be able to:
- Understand Linux architecture and the command line
- Manage users, groups, and permissions
- Handle package management and system updates
- Manage services and troubleshoot systems

What is Linux System Administration?

Linux Administration is the practice of managing and maintaining Linux systems — ensuring they run efficiently, securely, and reliably.

A Linux administrator is responsible for installing software, managing users and permissions, configuring services, monitoring performance, and troubleshooting issues across servers and networks.

Linux Operating System

What is Linux?

- An **open-source operating system** based on **UNIX**.
- Acts as the **bridge between hardware and applications**, managing processes, memory, and files.
- Used everywhere — from servers and smartphones to supercomputers and embedded systems.

Key Concepts:

- **Kernel:** The core that manages system resources and hardware communication.
- **Shell:** The command-line interface (CLI) that lets users interact with the system.
- **Filesystem:** The structured way Linux organizes and stores data.

Why Learn Linux?

- Powers over **90% of cloud servers** and **all major DevOps tools**.
- Essential for **system administrators, SREs, and developers**.
- Mastering Linux builds a foundation for automation, security, and cloud engineering.

Linux Operating System

🐧 Linux Distributions (Distros)

What is a Distro?
A Linux distribution is a complete operating system built around the Linux kernel, bundled with tools, libraries, and a package manager.

🔷 Major Families

Family	Example Distros	Package Manager
Debian-based	Ubuntu, Kali, Linux Mint	apt
Red Hat-based	RHEL, CentOS, Fedora, AmazonLinux	dnf / yum
SUSE-based	openSUSE, SUSE Linux Enterprise	zypper
Independent	Arch, Gentoo, Alpine	pacman, emerge, apk

💡 Notes

- Server admins often use **RHEL** or **Ubuntu LTS** for stability.
- Developers and hobbyists prefer **Fedora** or **Arch** for bleeding-edge updates.
- Cloud images (e.g., EC2 AMIs) are usually based on **RHEL**, **Amazon Linux**, or **Ubuntu**.

Linux Boot Process

1. BIOS / UEFI Initialization

- Hardware performs **Power-On Self Test (POST)**.
- Loads the **bootloader** from disk or firmware.

2. Bootloader (e.g., GRUB)

- Locates and loads the **Linux kernel** into memory.
- Passes control to the kernel with system parameters.

3. Kernel Initialization

- Detects hardware and mounts the **root filesystem** (/).
- Starts the **init process** (PID 1) — the first user-space program.

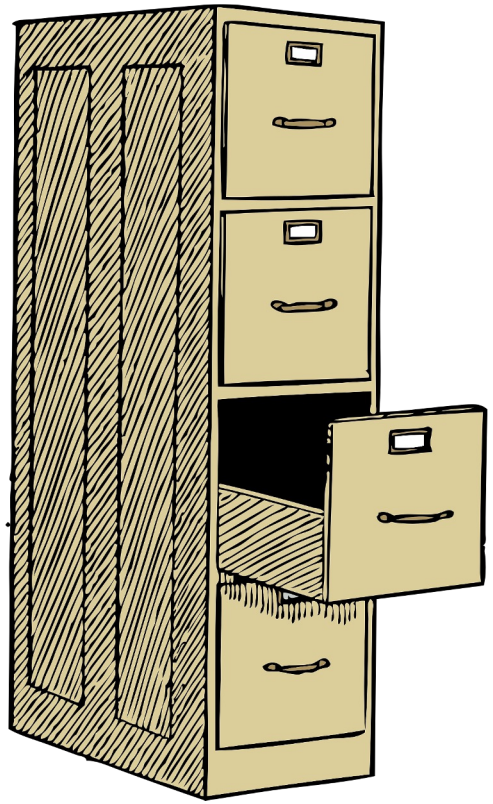
4. Init / Systemd

- Initializes system services and targets (networking, logging, etc.).
- Mounts remaining file systems and enables background daemons.

5. Login & Shell

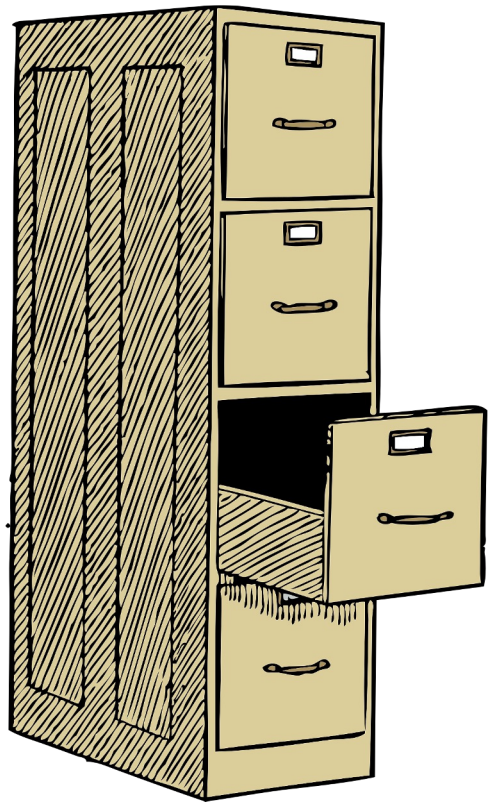
- Displays the **login prompt (TTY or GUI)**.
- After authentication, user enters a **shell session** ready for commands.

Linux Basics: File System



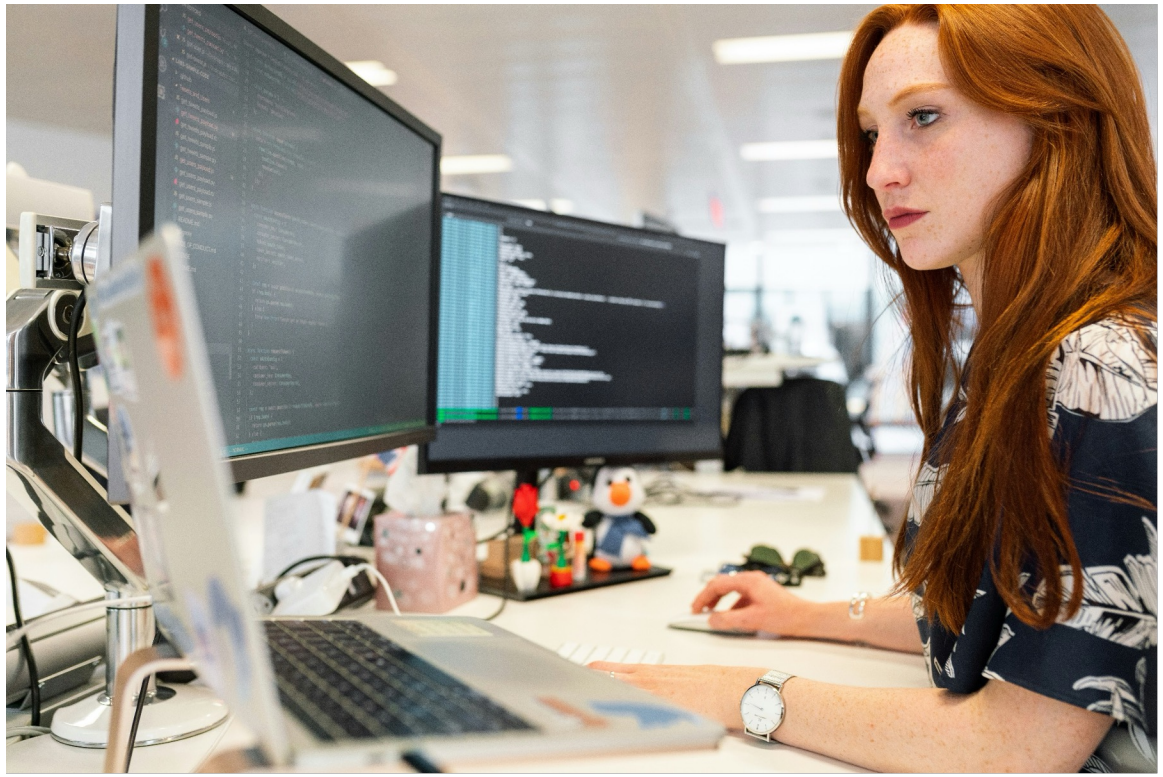
- File navigation is core to Linux administration and security. Administrators must be able to locate, inspect, and manage files efficiently — both for configuration and troubleshooting.
- The touch command creates a file or updates its timestamp, while ls -l displays file metadata such as permissions, ownership, and modification time — key for security auditing.
- Mastering navigation and file awareness is the first step toward mastering the system itself.

Linux Basics: File System



- Each subdirectory has a specific purpose:
  - /bin – Essential user commands (like `ls`, `cp`, `cat`).
  - /sbin – System administration binaries (like `ifconfig`, `reboot`).
  - **/etc** – System configuration files.
  - **/home** – User home directories.
  - **/root** – Home directory for the root user.
  - /var – Variable data (logs, mail, spool files).
  - /usr – User programs and read-only data (applications, libraries).
  - /tmp – Temporary files; cleared on reboot.
  - /dev – Device files representing hardware (disks, terminals).
  - /proc – Virtual filesystem providing process and kernel info.
  - /lib – Essential shared libraries for `/bin` and `/sbin`.
  - /boot – Files needed to boot the system (kernel, bootloader).
  - **/mnt** and **/media** – Mount points for removable or temporary storage.

Basic Commands



- Below are some basic commands to get started with
  - pwd, cd, ls, ls -la, history
  - mkdir, touch, cp, mv, rm, diff
  - echo, cat, history
- The Trick is to know how to use the manual and other shortcuts
  - man ls
  - Try using /all, enter and n and shift+n. Use g and shift+g.
  - Always look up the manual and options when encountering new commands and options.
  - Not all commands have a man page.
  - Tab Key is extremely useful for navigating files

Lab Work

💡 Working on Labs Effectively

Don’t just copy and paste commands.
Take time to **understand each option**, **read the man pages**, and **experiment with alternate approaches**.

Curiosity and exploration builds mastery.

Absolute vs Relative Path

Consider a house. To get to the kitchen, instructions may be **relative** to your current location (say a room), or from the front door (**absolute**).

cat /home/ubuntu/files/myfile.txt

- Always works, no matter working directory.

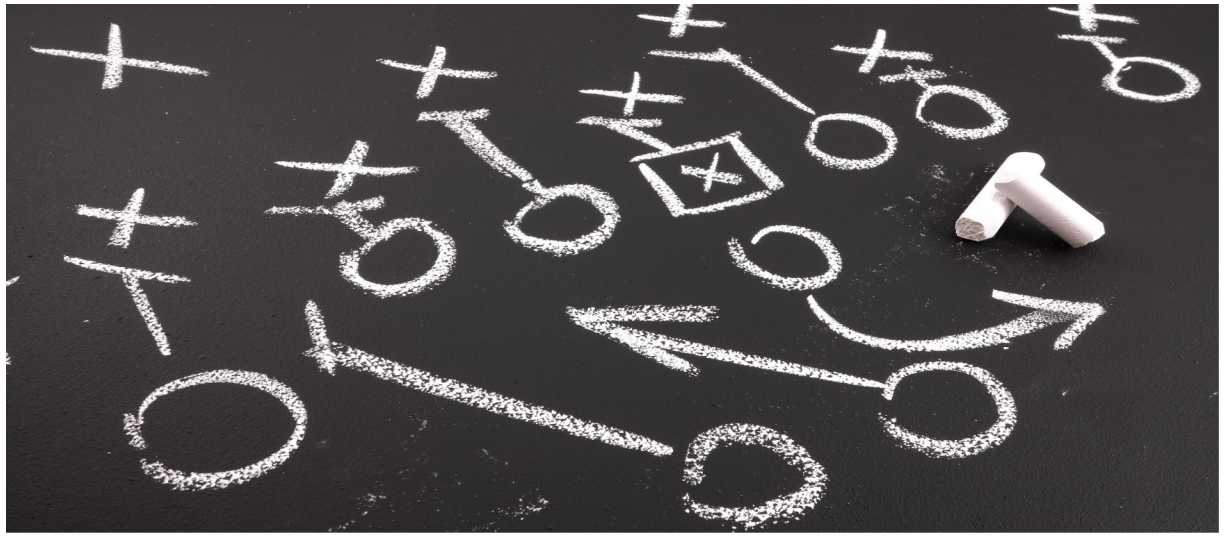
cat files/myfile.txt

- Only works if files/myfile.txt is in the working directory. If you change your working directory, this command will fail.

Safety with File Operations

Linux file systems do not come with recycle bins. As an administrator, you should be aware of backup options when running commands that may overwrite files.

- cp -b and mv -b make backups before overwriting any files
- rm -i will prompt a user to confirm file deletion

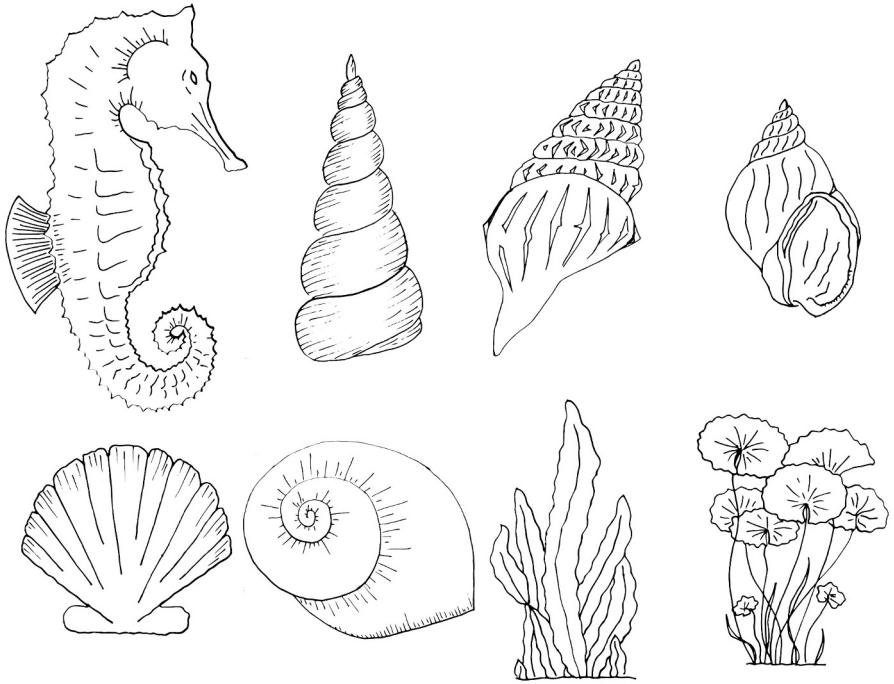


Shell Basics

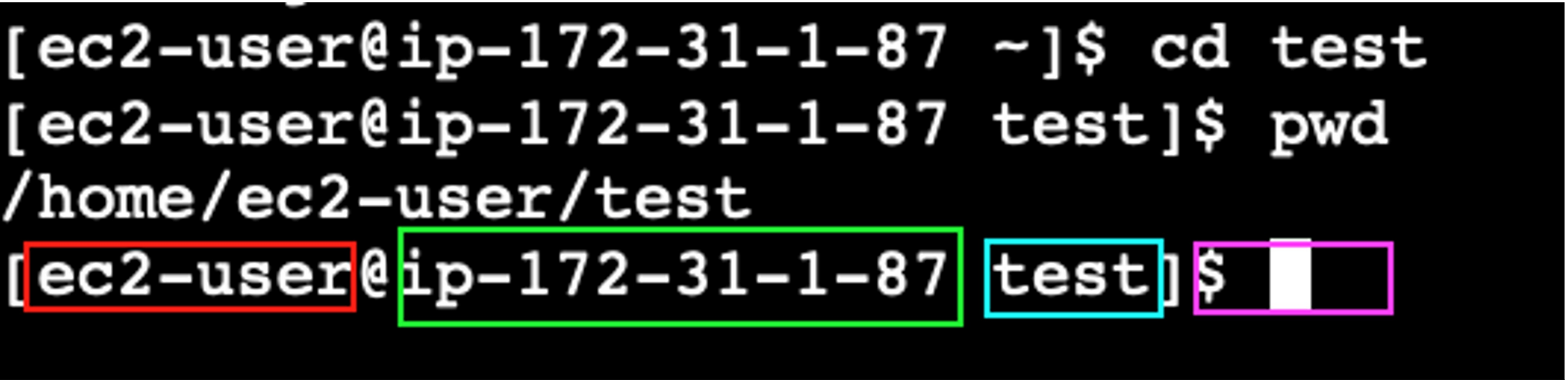
A shell is a **command-line interface** between the **user** and the **operating system**.
It **interprets commands** you type and **tells the OS what to do**.

Acts as a **wrapper around the kernel** — you don't talk to hardware directly.
Supports **scripting** for automation (.sh files).
Common types:

- **Bash** (most common on Linux)
- **Zsh**
- **Fish**
- **PowerShell** (Windows)



Shell Basics



- Username
- Host Address
- Working Directory
- Prompt (# for root user) - After the $ you enter a command

Basic Commands

```
[ec2-user@ip-172-31-1-87 ~]$ mkdir test
[ec2-user@ip-172-31-1-87 ~]$ cd test
[ec2-user@ip-172-31-1-87 test]$ echo "Hello World"
Hello World
[ec2-user@ip-172-31-1-87 test]$ echo "Hello World" > file.txt
[ec2-user@ip-172-31-1-87 test]$ echo "Hello Again" > file.txt
[ec2-user@ip-172-31-1-87 test]$ echo "Thank you" >> file.txt
[ec2-user@ip-172-31-1-87 test]$ cat file.txt
Hello Again
Thank you
[ec2-user@ip-172-31-1-87 test]$ cd ..
[ec2-user@ip-172-31-1-87 ~]$ ls -l
total 0
drwxr-xr-x. 2 ec2-user ec2-user 22 Oct 21 16:35 test
[ec2-user@ip-172-31-1-87 ~]$ rm -rf test
[ec2-user@ip-172-31-1-87 ~]$ ls -l
total 0
[ec2-user@ip-172-31-1-87 ~]$
```

Hidden Files

🏠 The Home Directory

- Your home folder may look **empty**, but `ls -a` reveals **hidden files** (those starting with `.`).
- These files aren't encrypted or protected — they're simply **tucked away** for convenience.

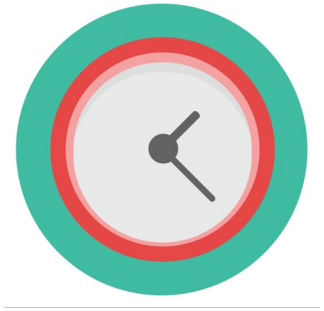
Common Hidden Files:

- `.bashrc` → runs each time you open a **new shell**
- `.bash_profile` → runs when you **log in**
- `.ssh/` → stores your **SSH keys** and authorized public keys for remote access

💡 *Hidden files often store configuration and authentication details — handle them with care!*

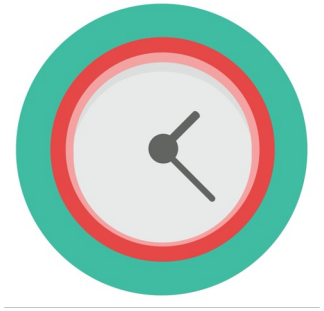
Lab 1.0 Connecting to Instance

Estimated Time: 15 Minutes



Lab 1.1 Linux File System

Estimated Time: 20 Minutes



POP QUIZ:

Which folder contains System Wide Configurations?

A. /bin
B. /var
C. /etc
D. /home

POP QUIZ:

Which folder contains System Wide Configurations?

A. /bin
B. /var
C. /etc
D. /home

"What about the other directories?"

POP QUIZ:

What command is used to rename a file in Linux?

A. nm
B. mv
C. cp
D. rename

POP QUIZ:

What command is used to rename a file in Linux?

A. nm
B. mv
C. cp
D. rename

"Can this be dangerous?"

POP QUIZ:

What option below will display long listing of all files?

A. ls -l
B. ls -ap
C. echo pwd
D. ls -la

POP QUIZ:

What option below will display long listing of all files?

A. ls -l
B. ls -ap
C. echo pwd
D. ls -la

"What about ls -l -a?"

Linux: File Attributes

Files come with attributes, such as ownership, permissions, type, size, and last touch time.

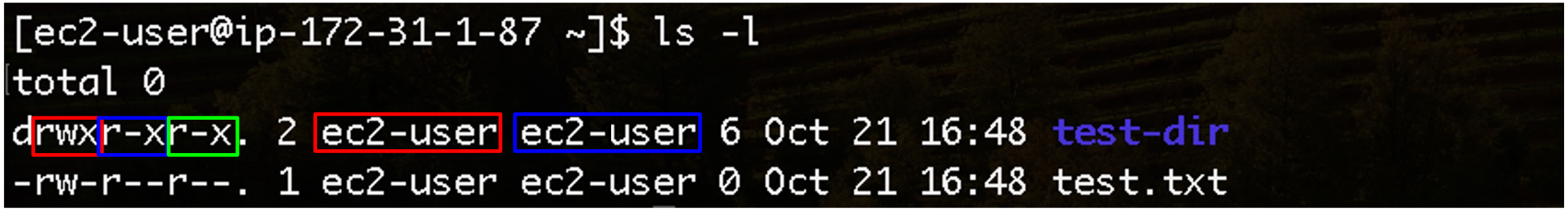
System Administrators must understand these attributes to manage access, ensure security, troubleshoot issues, and maintain proper system organization.

Linux: File Permissions

Symbol	Permission	Description	Numeric Value
r	Read	Can view or read file	4
w	Write	Modify or delete file	2
x	Execute	Can execute the file	1
-	No Permission	No access	0

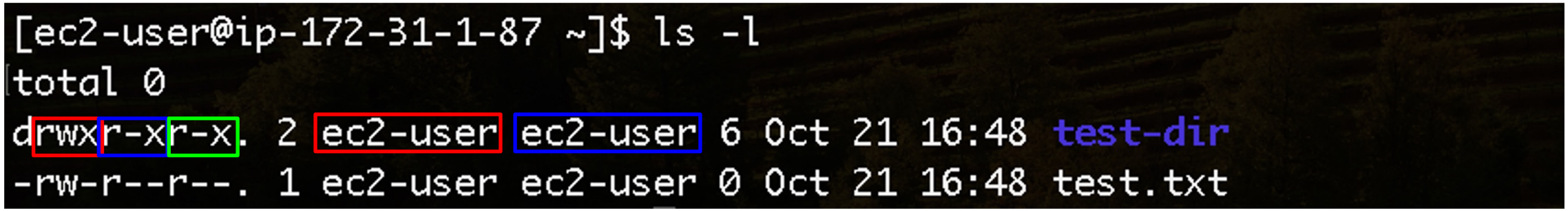
```
[ec2-user@ip-172-31-1-87 ~]$ ls -l
total 0
drwxr-xr-x. 2 ec2-user ec2-user 6 Oct 21 16:48 test-dir
-rw-r--r--. 1 ec2-user ec2-user 0 Oct 21 16:48 test.txt
```

Linux: File Permissions



- First set of bits in red belong to the user (file owner). The file owner is also indicated in red.
- The blue set of bits is for the group. The file belongs to the group indicated in blue (defaults group is user who created the file)
- The third set of permissions is other users

Linux: File Permissions

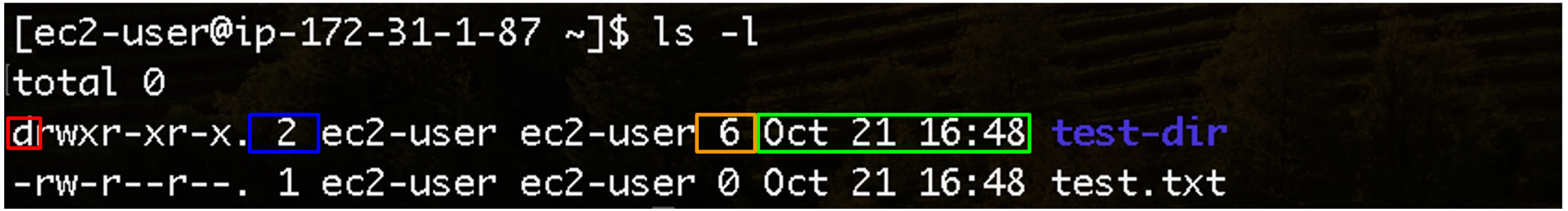


The permissions for test-dir are 755

- r(4) + w(2) +x(1) = 7
- r(4) + x(1) = 5
- r(4) + x(1) = 5

What are the permissions for test.txt?

Linux: File Permissions



- The first char is the file type. Empty indicates ordinary file, d for directory
- The second blue box indicates the number of links to a file
- The third orange box represents the file size estimate
- The last green box is a timestamp of when the file was last touched

Linux: File Types

- **Regular File (-)** – Text, data, or binary programs
- **Directory (d)** – Holds files or other directories
- **Symbolic Link (l)** – Shortcut pointing to another file
- **Character Device (c)** – Hardware sending data one character at a time (e.g., keyboard)
- **Block Device (b)** – Hardware that transfers data in blocks (e.g., disk drives)
- **Named Pipe (p)** – Communication between running processes
- **Socket (s)** – Network or inter-process communication endpoint

Changing File Permissions

The chmod (**change file mode bits**) command is used to **modify file or directory permissions**.
It can be used in two ways:

- **Numeric (absolute)** — set exact permissions using numbers
  a. chmod 755 file.sh
  b. Sets permissions to **rwxr-xr-x**
- **Symbolic (relative)** — adjust permissions using letters and operators
  a. chmod u-x file.sh
  b. Would simply subtract execute to the user of the file **rw-r-xr-x**

💡 *Sysadmins use chmod to control who can read, write, or execute files on the system.*

Linux: File Execution

- To execute a file, it must be executable, and you must have permissions to execute.
- You can add the executable file to a directory in $PATH variable if you would like make script globally executable.
- Do not be fooled by source command. It does not execute a script, it simply runs the commands in a file line by line in current shell.

Linux: File Execution

```
[ec2-user@ip-172-31-1-87 ~]$ chmod +x my_script.sh
[ec2-user@ip-172-31-1-87 ~]$ ls -l my_script.sh
-rwxr-xr-x. 1 ec2-user ec2-user 17 Oct 21 17:54 my_script.sh
[ec2-user@ip-172-31-1-87 ~]$ ./my_script.sh
hello world
[ec2-user@ip-172-31-1-87 ~]$ echo $PATH
/home/ec2-user/.local/bin:/home/ec2-user/bin:/usr/local/bin:/usr/bin:/usr/local/sbin:/usr/sbin
[ec2-user@ip-172-31-1-87 ~]$ mkdir -p bin
[ec2-user@ip-172-31-1-87 ~]$ mv my_script.sh bin/my_script.sh
[ec2-user@ip-172-31-1-87 ~]$ cd test-dir/
[ec2-user@ip-172-31-1-87 test-dir]$ my_script.sh
hello world
[ec2-user@ip-172-31-1-87 test-dir]$
```

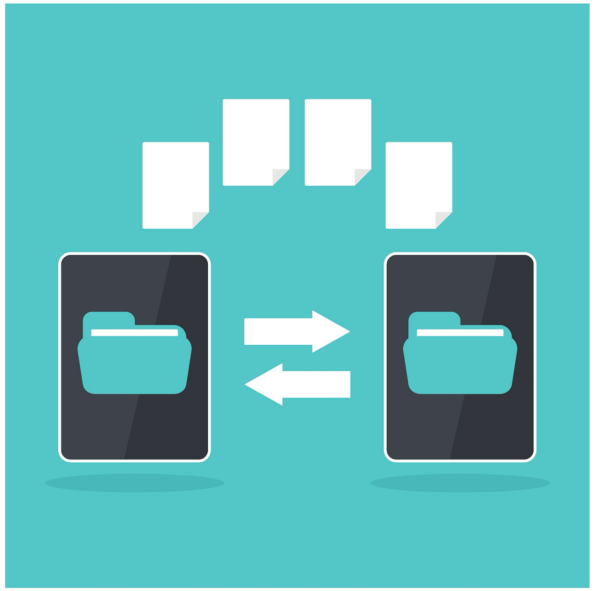
Linux: Links

A **link** is a reference that points to another file or directory, allowing multiple names or paths to access the same data.

🔗 Hard vs Soft Links

- **Hard Link:** Created with `ln file linkname`
  → Points to the **same inode** (actual data).
  → If the original file is deleted, the link **still works**.
  → Essentially two names for the same file.
- **Soft (Symbolic) Link:** Created with `ln -s file linkname`
  → Points to the **file's path**, not its data.
  → If the original file is deleted, the link **breaks**.
  → Works like a **shortcut** or **alias**.

💡 *Hard links share data; soft links reference the path.*



Linux: File Stat

The stat command displays **detailed information** about a file or directory beyond what ls -l shows.

Key fields explained:

- **File:** Name and type (regular file, directory, link, etc.)
- **Size:** File size in bytes
- **Inode:** Unique ID for the file's data on disk
- **Links:** Number of hard links pointing to the inode
- **Access (Permissions):** Shows mode in both symbolic and numeric form
- **UID / GID:** Owner and group IDs
- **Access / Modify / Change:**
  - **Access** → Last read time
  - **Modify** → Last content change
  - **Change** → Last metadata change

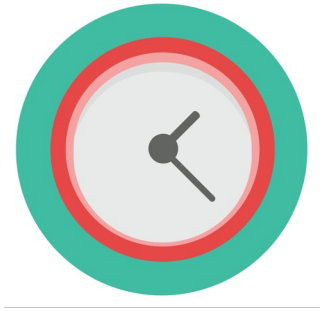
💡 *stat gives a full snapshot of a file's identity and history.*

Linux: File Stat

```
[ec2-user@ip-172-31-1-87 ~]$ stat test.txt
  File: test.txt
  Size: 0               Blocks: 0          IO Block: 4096   regular empty file
Device: 10301h/66305d   Inode: 8536241     Links: 1
Access: (0644/-rw-r--r--)  Uid: ( 1000/ec2-user)   Gid: ( 1000/ec2-user)
Context: unconfined_u:object_r:user_home_t:s0
Access: 2025-10-21 16:48:32.734814761 +0000
Modify: 2025-10-21 16:48:32.734814761 +0000
Change: 2025-10-21 16:48:32.734814761 +0000
 Birth: 2025-10-21 16:48:32.734814761 +0000
[ec2-user@ip-172-31-1-87 ~]$
```

Lab 1.2 File Details

Estimated Time: 30 Minutes



POP QUIZ:

Which is the correct permission bits below for 701?

A. r w x - - - - - - x
B. r w x r w x r w x
C. - - x - - - r w x
D. None of the above

POP QUIZ:

Which is the correct permission bits below for 701?

A. r w x - - - - - - x
B. r w x r w x r w x
C. - - x - - - r w x
D. None of the above

"Will a user who is not the owner, but in the group, be able to execute?"

POP QUIZ:

Which statement about Linux file links is **true**?

A. A soft link points directly to the file's inode.
B. A hard link becomes invalid if the original file is deleted.
C. A soft link stores the path to the original file.
D. A hard link can reference files on different file systems.

POP QUIZ: Which statement about Linux file links is **true**?

"What are links again?"

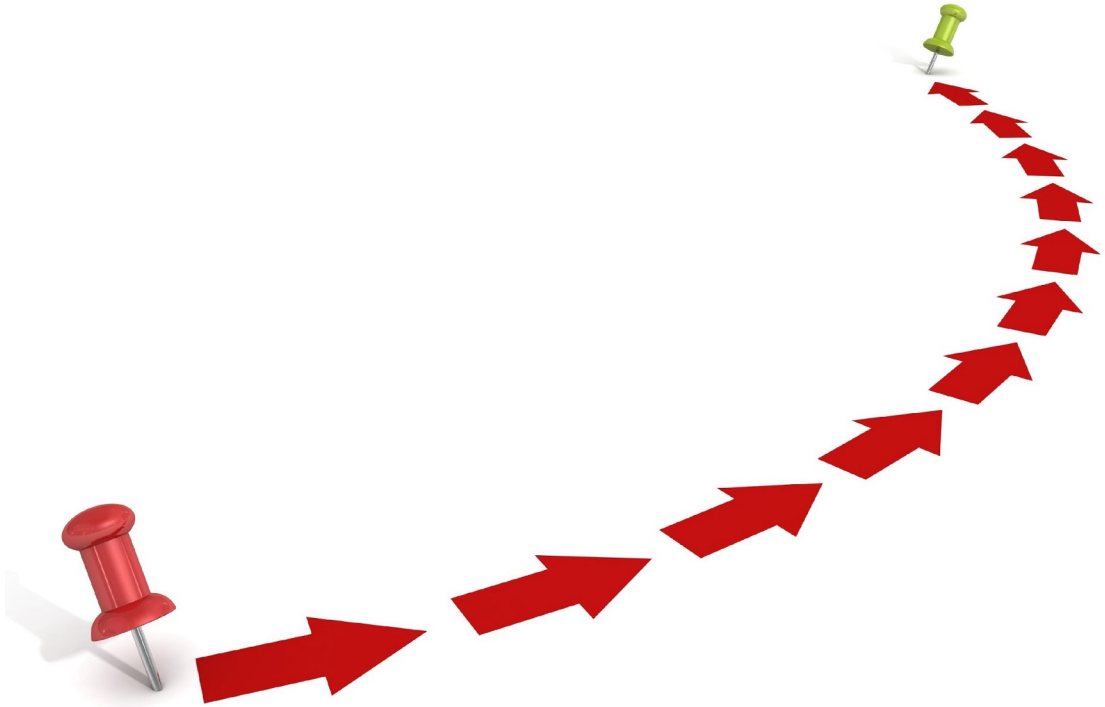
A. A soft link points directly to the file's inode.
B. A hard link becomes invalid if the original file is deleted.
C. A soft link stores the path to the original file.
D. A hard link can reference files on different file systems.

Linux: File Processing and Compression

It is not enough to manage file attributes. Effective system administrators must also be able to **process, view, and manipulate file contents** efficiently.

This includes using commands like cat, tac, head, tail, and less to read files, as well as tools to **redirect, filter, and compress data** for storage, analysis, or transfer.

Linux: File Redirection



🔄 File Redirection

- Controls **where input and output go**
- Sends command results to files instead of the screen

Common Operators:

- `>` Write (overwrite) output to file
- `>>` Append output to file
- `<` Take input from file
- `2>` Redirect errors
- `&>` Redirect output **and** errors

💡 *Use redirection to save results, capture logs, or process data automatically.*

Linux: Reading Files

📖 Reading Files

- View or scroll through file contents in the terminal

Common Commands:

- cat file.txt → Display file contents
- tac file.txt → Display contents **in reverse**
- less file.txt → Scroll and search inside file
- more file.txt → View file one screen at a time

Searching in less:

- Press / then type a word → search **forward**
- Press ? then type a word → search **backward**
- Use n / N to move to next or previous match

💡 *less is best for reading large files interactively.*

Linux: Reading Files

```
[ec2-user@ip-172-31-1-87 ~]$ echo "Header of my file" > data.txt
[ec2-user@ip-172-31-1-87 ~]$ echo "New header of my file" > data.txt
[ec2-user@ip-172-31-1-87 ~]$ echo "Linux is fun" >> data.txt
[ec2-user@ip-172-31-1-87 ~]$ cat data.txt
New header of my file
Linux is fun
[ec2-user@ip-172-31-1-87 ~]$ tac data.txt
Linux is fun
New header of my file
[ec2-user@ip-172-31-1-87 ~]$ tac data.txt > data.rev
[ec2-user@ip-172-31-1-87 ~]$ cat data.txt
New header of my file
Linux is fun
[ec2-user@ip-172-31-1-87 ~]$ cat data.rev
Linux is fun
New header of my file
[ec2-user@ip-172-31-1-87 ~]$ cat notafile.txt
cat: notafile.txt: No such file or directory
[ec2-user@ip-172-31-1-87 ~]$ cat notafile.txt 2> error.log
[ec2-user@ip-172-31-1-87 ~]$ cat notafile.txt > result.log
cat: notafile.txt: No such file or directory
[ec2-user@ip-172-31-1-87 ~]$ cat result.log
[ec2-user@ip-172-31-1-87 ~]$ cat error.log
cat: notafile.txt: No such file or directory
[ec2-user@ip-172-31-1-87 ~]$
```

Linux: Reading Files

📄 Viewing File Sections

Sometimes you only need the **first** or **last** few lines of a file.
Use:

- head -n ⟶ shows the **first n lines**
- tail -n ⟶ shows the **last n lines**

Example:

ls -ltr | tail -1

➡️ Returns the **most recently modified file** in the current directory.

💡 *Perfect for checking logs or large outputs quickly.*

Linux: grep command

🔍 The grep Command

The grep command searches files for **lines matching a pattern**.

Basic use:
grep "error" logfile.txt

- → Prints lines containing the word *error*.

Search all files in a folder:
grep "error" *

Search recursively through subfolders:
grep -r "error" /var/log

💡 *Great for finding configurations, debugging errors, or locating specific text anywhere on your system.*

Linux: grep examples

```
[ec2-user@ip-172-31-1-87 ~]$ grep "debug" /var/log/cloud-init.log -ic # counts number of lines with debug
957
[ec2-user@ip-172-31-1-87 ~]$ grep "debug" /var/log/cloud-init.log -i | tail -2 # prints last 2 lines
2025-10-20 21:19:58,137 - cc_power_state_change.py[DEBUG]: cmdline changed for 1611 [now: None]
2025-10-20 21:19:58,142 - cc_power_state_change.py[DEBUG]: check_condition command (test -f /run/cloud-init-se
linux-reboot): exited 1. condition not met.
[ec2-user@ip-172-31-1-87 ~]$ sudo grep "error" /var/log -ilr # prints every file name with error
/var/log/dnf.log
/var/log/dnf.rpm.log
/var/log/journal/ec21f4760dd031654c602cf85faff450/system.journal
/var/log/journal/ec21f4760dd031654c602cf85faff450/user-1000.journal
/var/log/chrony/tracking.log
/var/log/amazon/ssm/amazon-ssm-agent.log
/var/log/amazon/ssm/errors.log
/var/log/dnf.librepo.log.1
[ec2-user@ip-172-31-1-87 ~]$
```

Linux: More File Commands

🔢 Working with Text: wc, sort, uniq

wc
Counts **lines, words, and characters** in a file.

```
wc file.txt
wc -l file.txt   # lines only
```

sort
Arranges lines in **alphabetical or numerical order**.

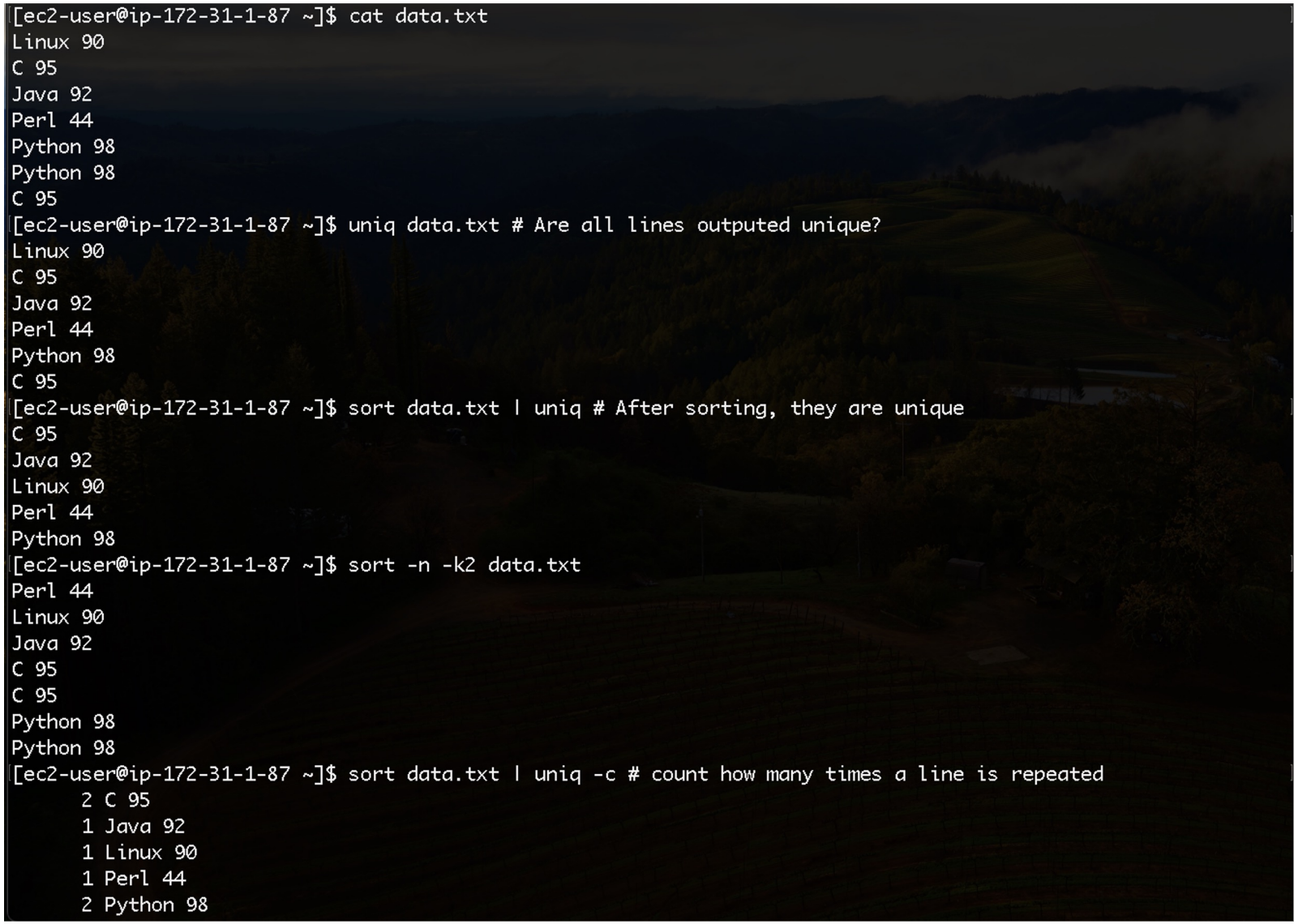
```
sort names.txt
sort -r names.txt   # reverse order
```

uniq
Filters out **repeated lines** (works best after sort).

```
sort names.txt | uniq
```

💡 *Combine them for quick text analysis and cleanup!*

Linux: More File Commands



Linux: File Differences

⚖️ The diff Command

Compares **two files line by line** and shows what's different.

Example:

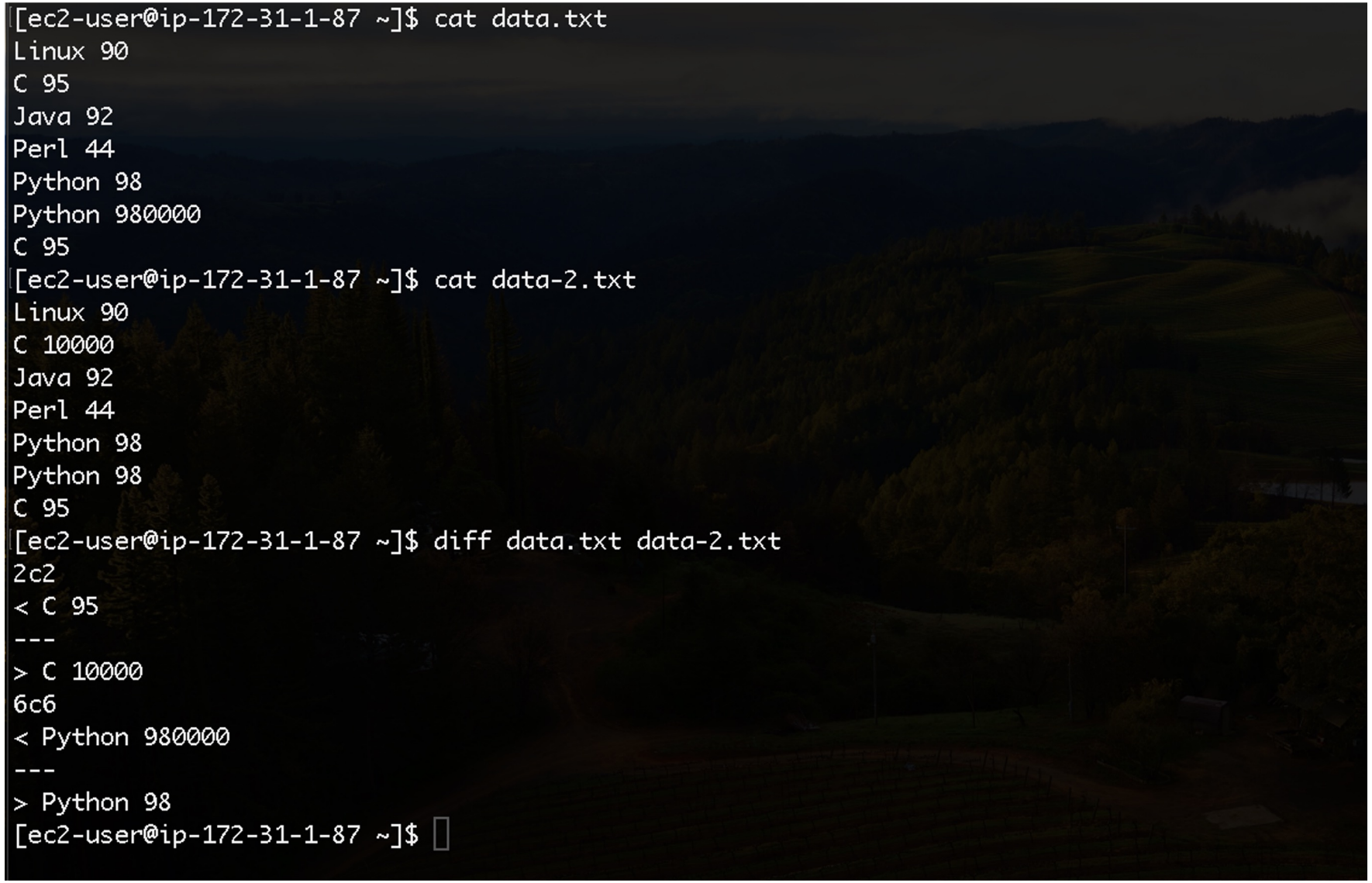
```
diff file1.txt file2.txt
```

Symbols:

- < → Line only in the **first file**
- > → Line only in the **second file**

💡 *Use diff to track changes, compare configs, or debug edits between versions.*

Linux: File Differences



Linux: File Differences

📦 The tar Command

Used to **archive** (and optionally compress) multiple files into one package.

Common Uses:

Create an archive:
`tar -cvf backup.tar folder/`

Extract an archive:
`tar -xvf backup.tar`

Create a compressed archive:
`tar -czvf backup.tar.gz folder/`

Extract a compressed archive:
`tar -xzvf backup.tar.gz`

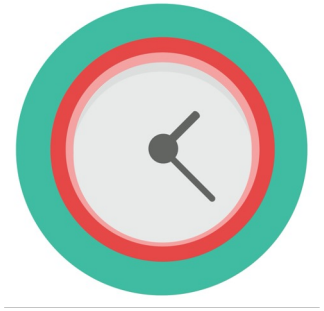
Flags:

- `c` = create `x` = extract `v` = verbose `f` = filename `z` = gzip

💡 *tar bundles files for easy backup, sharing, or compression.*

Lab 1.3 File Processing and Compression

Estimated Time: 40 Minutes



POP QUIZ:

Which of these tar commands creates a compressed archive?

A. tar -xvf files.tar.gz
B. tar -czvf files.tar.gz folder/
C. tar -cvf files.tar folder/
D. tar files.tar.gz folder/.

POP QUIZ:

Which of these tar commands creates a compressed archive?

A. tar -xvf files.tar.gz
B. tar -czvf files.tar.gz folder/
C. tar -cvf files.tar folder/
D. tar files.tar.gz folder/.

"What does the -z do?"

POP QUIZ:

In diff file1 file2, what does the < symbol mean?

A. Line only in second file
B. Line only in first file
C. Line exists in both
D. Line is newer

POP QUIZ:

In diff file1 file2, what does the < symbol mean?

A. Line only in second file
B. Line only in first file
C. Line exists in both
D. Line is newer

"What gets printed if line exists in both files?"

POP QUIZ:

Which command finds lines containing “error” in all files of a directory?

A. grep error /var/log
B. grep -r error /var/log
C. find "error" /var/log
D. search error /var/log

POP QUIZ:

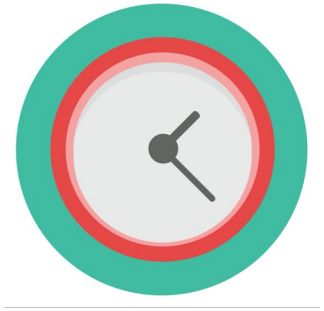
Which command finds lines containing “error” in all files of a directory?

A. A. grep error /var/log
B. B. grep -r error /var/log
C. C. find "error" /var/log
D. D. search error /var/log

“What does -r do?”

Lab 1.4 File Processing Challenge

Estimated Time: 30 Minutes



Linux Day 1 Complete

🧭 Today You Learned

- How to **navigate** the Linux file system
- About different file types and how to process them
- How to **redirect input and output**
- How to **archive and compress** files using tar

💡 *You now have the essentials to explore, manage, and process files confidently from the Linux command line!*