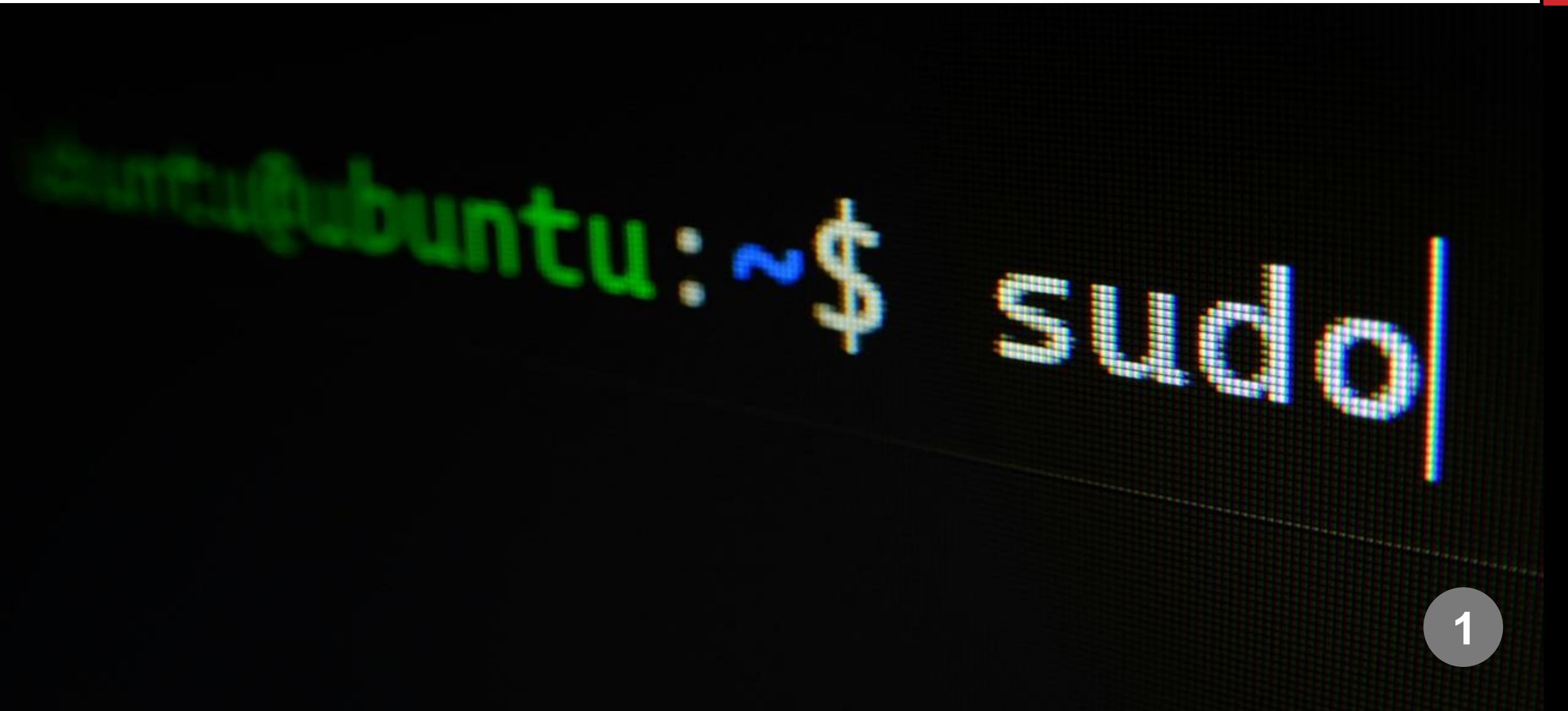
Linux: System Administration



LOGISTICS

Class Hours:

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

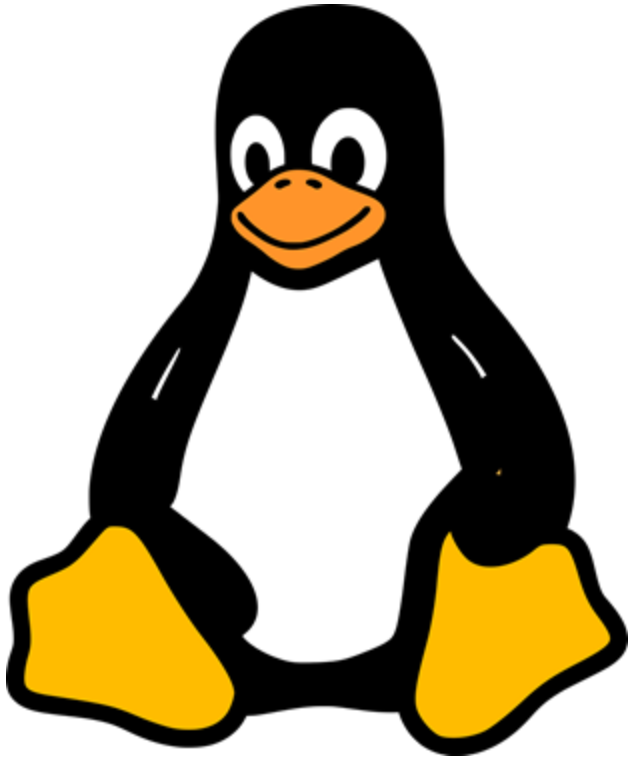
Telecommunication:

- Turn off or set electronic devices to silent (not vibrate)

Learning:

- Run the commands with the instructor as the slides are presented to you
- Ask questions and participate

Todays Objectives



1. **Become comfortable editing files with VI**
2. **Learn essential commands and skills for system monitoring**
3. **Understand how manage Linux Jobs and Processes**
4. **Apply operators and command chaining**

Image from OpenClipart-Vectors from Pixabay. Based on Tux design by Larry Ewing (lewing@isc.tamu.edu) and The GIMP

Learning Commands

You will learn **many new commands** throughout this course.
Don't focus on memorizing them all — instead, focus on **understanding their purpose.**

Ask yourself:
"What problem does this command solve?"

When you face a challenge, **look for the right command** to help you solve it.
Always read the manual for new commands and options:

```
man <command>
```

To see **all available commands** on your system:

```
compgen -c
```

💡 *Mastery in Linux comes from curiosity and practice — not memorization.*

Linux: File Editing

Editing files is one of the **most basic and essential** system administration skills.

Why it matters:

- Configuration files control almost **everything** — networking, services, security, and startup behavior.
- Quick edits can **fix problems** or **apply changes** without reinstalling software.
- Many servers are **CLI-only** — you won't always have a GUI text editor.

Editing Files with VI

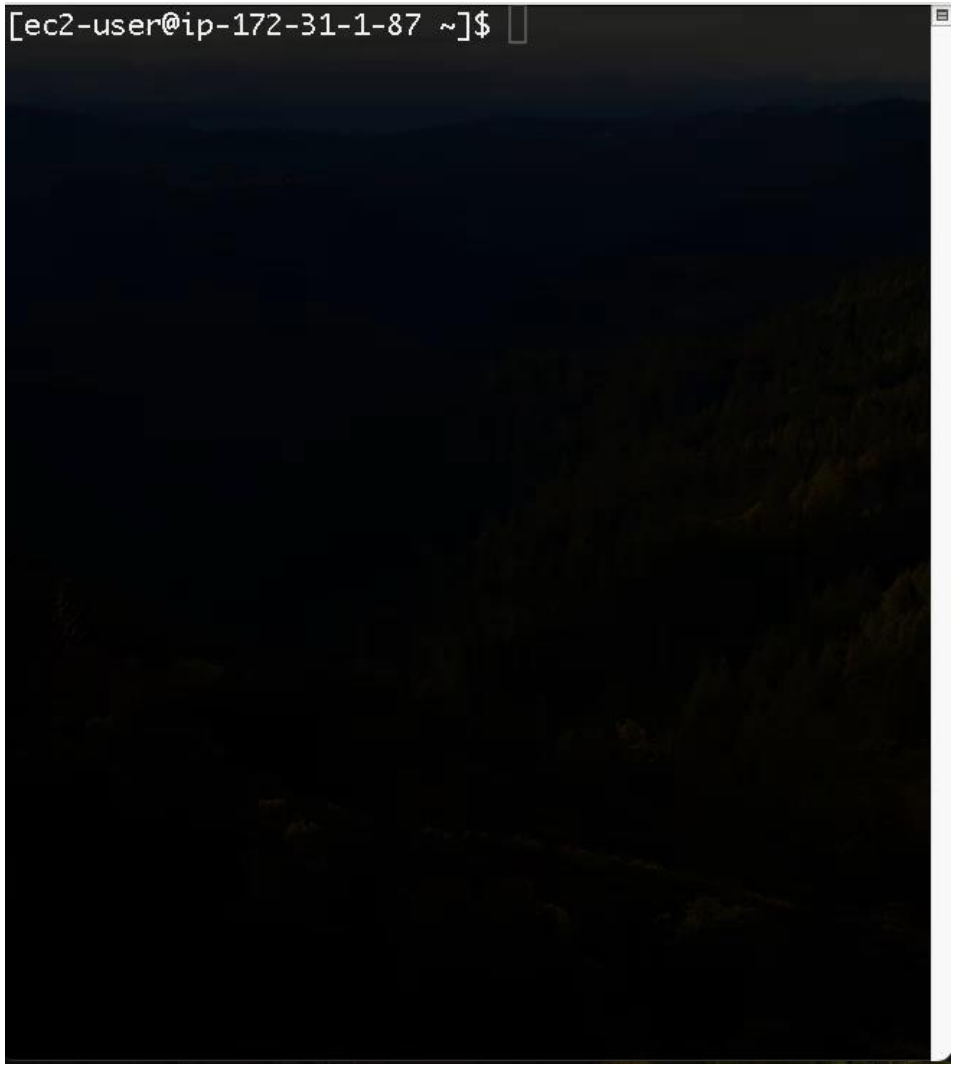
🧠 Why Learn **VI / VIM**

What It Is:

- **Vim (Vi Improved)** – a terminal-based **text editor** derived from the original *vi*.
- Available on virtually **every Linux/Unix system** — no installation needed.

Why It Matters:

- 📄 **Always Available** – found on all servers; perfect for SSH sessions.
- ⚡ **Fast & Lightweight** – no GUI overhead, runs even on minimal systems.



Video: VI Demo

Editing Files with VI

Understanding the VI/VIM Demo

In the demo, we edited a file using just the keyboard:

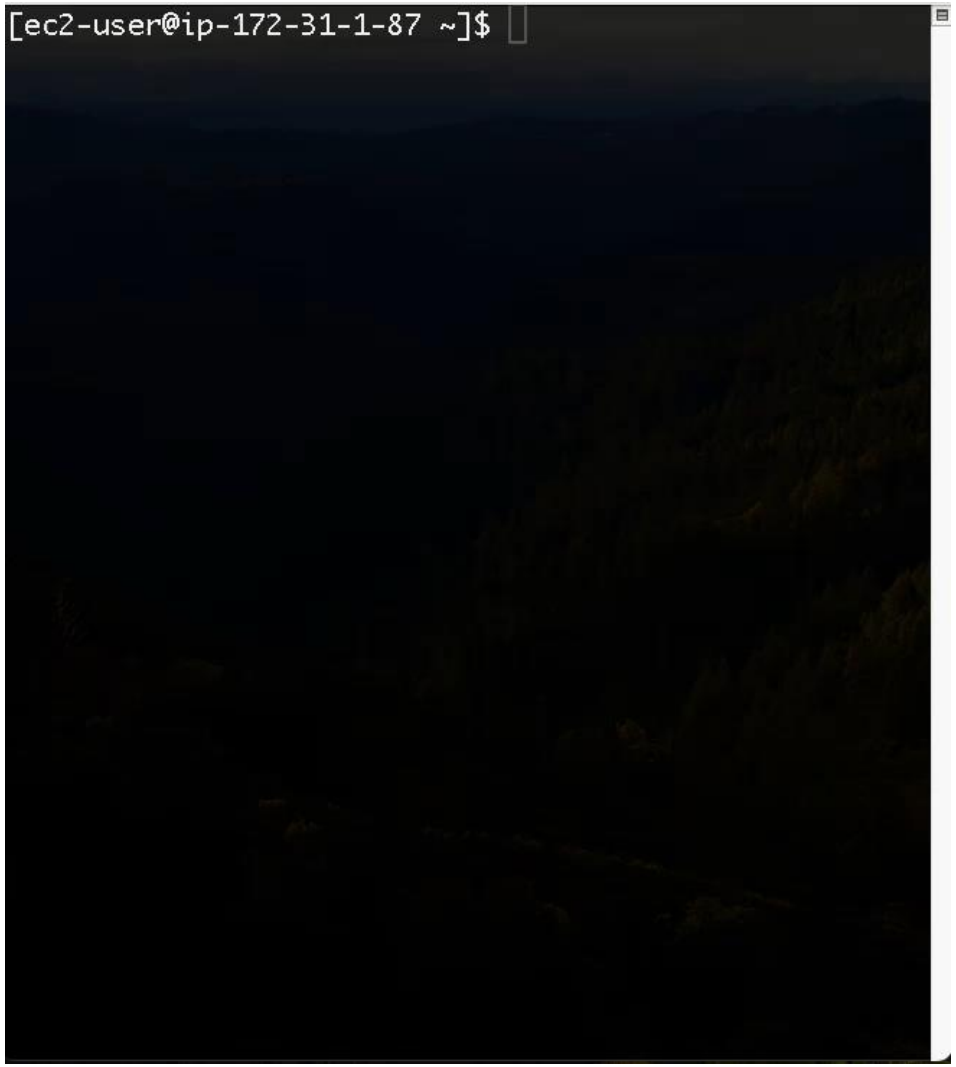
- `i` → **Insert Mode**

  Enables typing text into the file.
- `Esc` → **Command Mode**

  Exits editing and returns control to VIM commands.
- `:wq` → **Write & Quit**

  Saves the file (`w`) and exits (`q`).

💡 **Key Idea:**
VIM uses modes — you switch between typing text and running commands. Once you learn the shortcuts, it's one of the **fastest editors** you can use on any server.



Video: VI Demo

Editing Files with VI

⚡ Common VI/VIM Shortcuts (beginner)

Navigation
- **g** → Go to the **top** of the file
- **G** → Go to the **bottom** of the file

Editing
- **yy** → Copy (yank) a line
- **p** → Paste the copied line
- **dd** → Delete the current line
- **u** → Undo
- **Ctrl+r** → Redo

Exit
- **:wq** → Write (save) and quit (exit)
- **:q!** → Quit **without saving**

💡 *Tip: These are all you need to start feeling comfortable moving around and editing files in VIM.*

Editing Files with VI

🔍 Search & Replace in VI/VIM

Searching

- `/word` → Search **forward** for “word”
- `n` → Jump to the **next** match
- `N` → Jump to the **previous** match

Replacing

- `:%s/old/new/g` → Replace **all** occurrences of “old” with “new” in the file
- `:s/old/new/` → Replace only in the **current line**

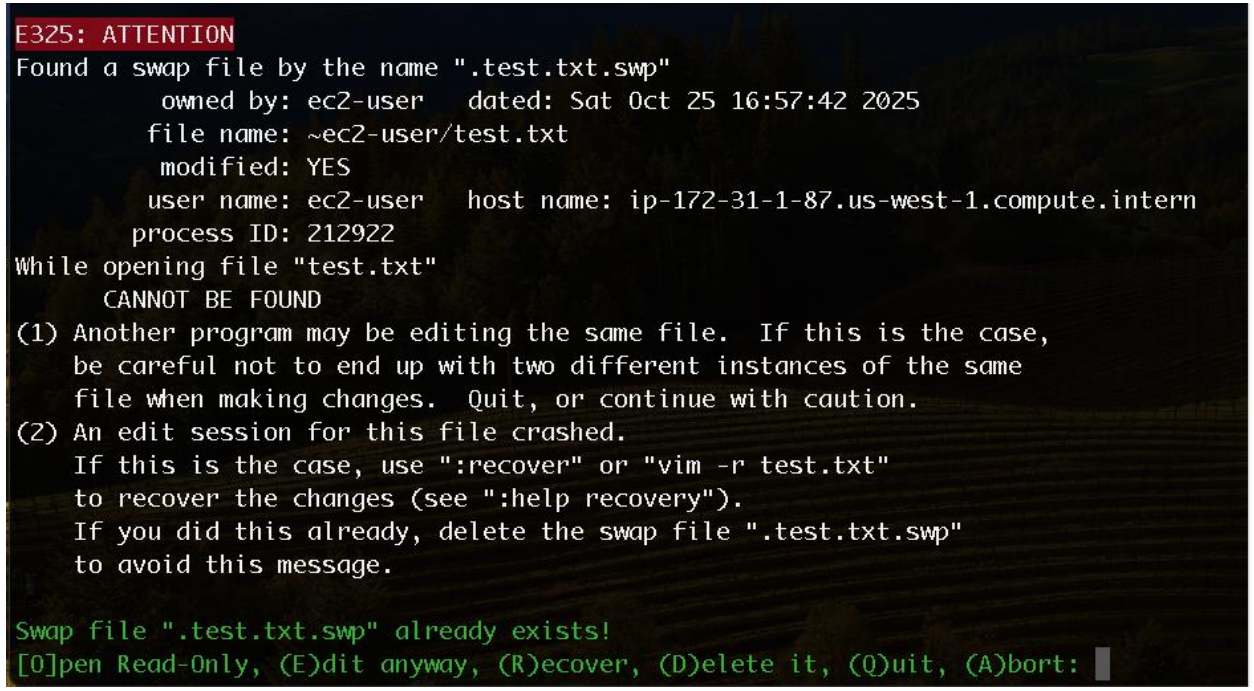
💡 **Note:**
Search and replace commands make VIM extremely powerful — you can modify hundreds of lines in seconds.

Editing Files with VI

⚠️ **Don’t Panic if you see this screen**

Vi simply creates a backup if the editor exits unexpectedly.

- R to recover the unsaved file
- D to delete the backup
- E to edit the saved version



Lab 1.0 Editing Files

Estimated Time: 20 Minutes

Tip: Try the `vimtutor` command. It will teach you how to use vim.

POP QUIZ:

What key takes you into Normal mode in vi?

A. n
B. esc
C. nm
D. enter

POP QUIZ:

What key takes you into Normal mode in vi?

A. n
B. esc
C. nm
D. enter

"What can you do in normal mode?"

POP QUIZ:

How can I properly exit a file without saving?

A. Close the terminal session
B. :q
C. :qq
D. :q!

POP QUIZ:

How can I properly exit a file without saving?

A. Close the terminal session
B. :q
C. :qq
D. :q!

"What happens if we close the terminal session?"

POP QUIZ:

What is the proper way to save and exit a file?

A. :wq
B. :save
C. :w
D. :zz

POP QUIZ:

What is the proper way to save and exit a file?

A. :wq
B. :save
C. :w
D. :zz

"How can I save without exiting?"

Linux: System Monitoring

System monitoring is how administrators stay ahead of problems. It reveals what the system is doing behind the scenes — which processes are using resources, how the network is behaving, and whether performance is steady or degrading over time. Without monitoring, issues are discovered only after users are affected.

A good admin doesn’t guess; they observe. Knowing how to monitor your system means you can diagnose issues quickly, plan capacity intelligently, and maintain reliability with confidence.

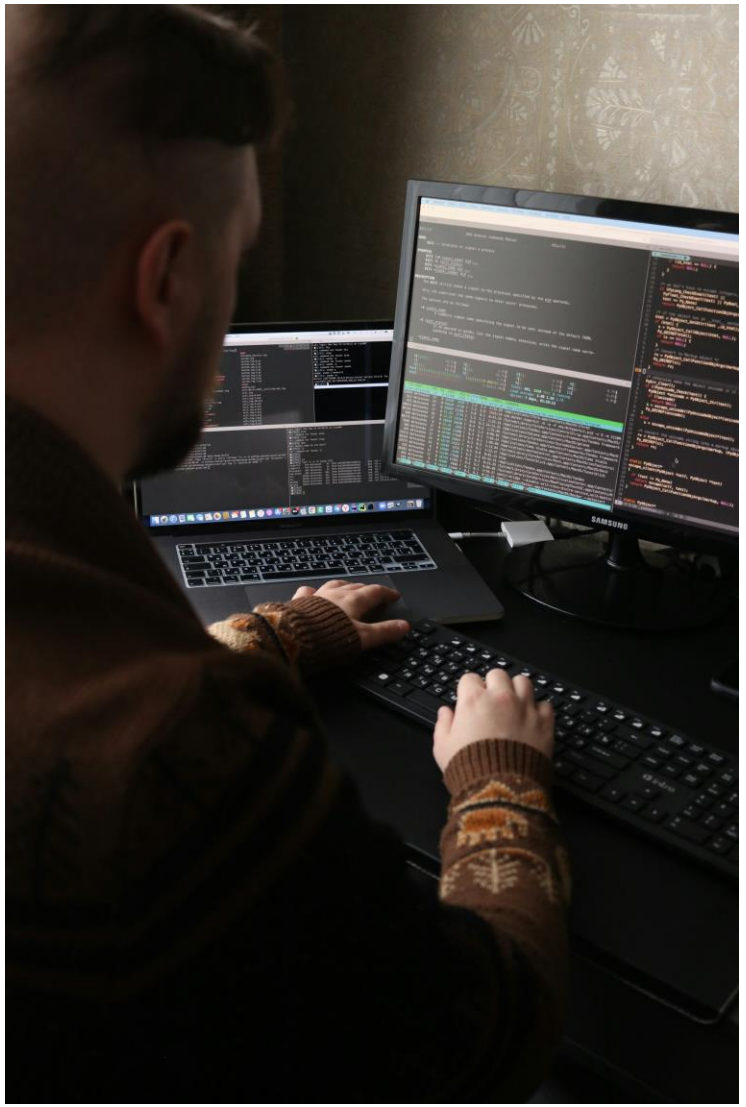
System Monitoring

System monitoring is the practice of observing and analyzing system performance to ensure reliability, availability, and efficiency.

Why It Matters:

- Detect issues before they cause downtime
- Understand how CPU, memory, disk, and network resources are used
- Set up alerts for unusual activity or failures
- Support capacity planning and performance tuning
- Improve visibility for security and compliance

💡 **Key Takeaway:**
Monitoring turns system data into actionable insights — it's how engineers maintain stability and prevent outages.



Linux Operating System

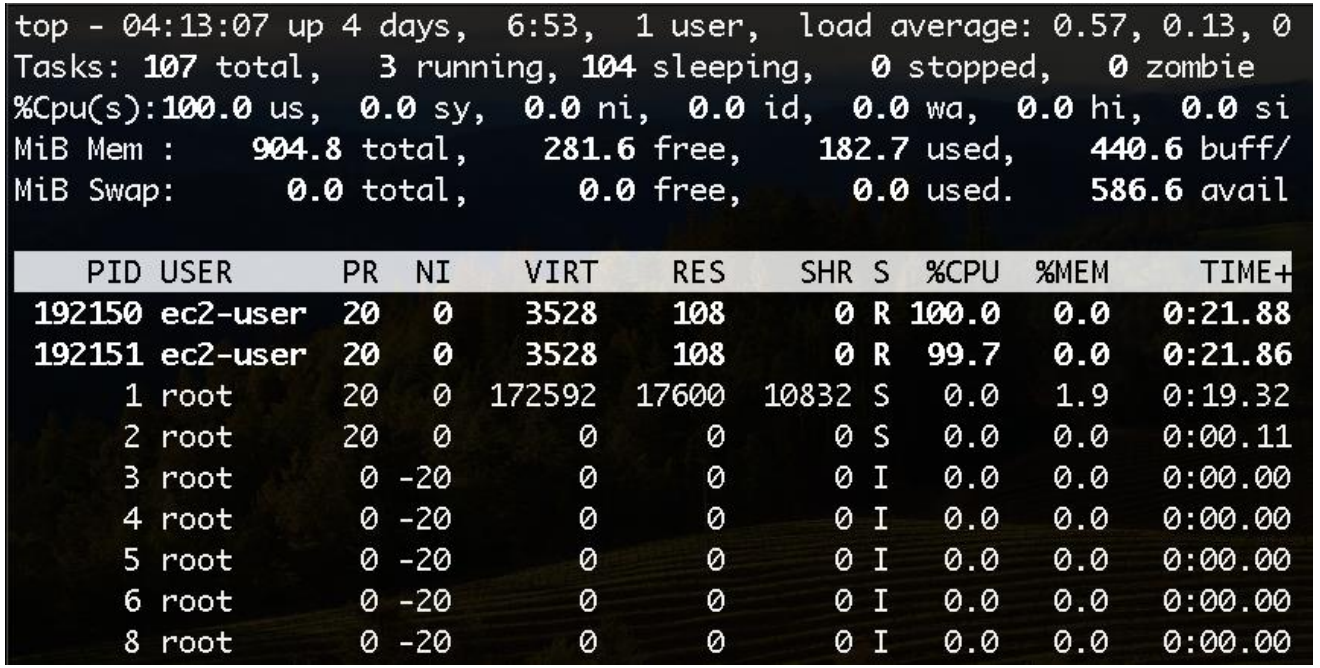
The `top` Command

A foundational monitoring command in Linux is **`top`**.

It provides a real-time view of CPU, memory, and process activity.
Try sorting the display:

- Press **`P`** → sort by **CPU usage**
- Press **`M`** → sort by **Memory usage**

💡 *Great for a quick snapshot of system health*



Linux Processes

Program vs Process

Program
- A **set of instructions** stored on disk (e.g., `/usr/bin/python`)
- **Passive** — it does nothing until executed
- Exists as a **file**, not yet in memory

Process
- A **running instance** of a program
- **Active** — currently executing on the CPU
- Has its own **PID (Process ID)**, memory space, and entry in the **process table**
- Created when a program is launched

💡 *In short: A program is the recipe; a process is the dish being cooked.*

Linux Processes

Simulating Load with the `stress` Command

Purpose:
stress is a simple workload generator used to simulate **CPU, memory, and I/O pressure** — ideal for practicing monitoring and performance analysis.

Example Usage:

```
sudo dnf install stress -y    # or apt install stress
stress --cpu 2 --vm 1 --vm-bytes 128M --timeout 60s &
```

This command:

- Creates **2 CPU workers**
- Allocates **128 MB of memory**
- Runs for **60 seconds**
- Great for creating processes to view with `top`

Linux Processes

The `ps` Command

ps (process status) displays **information about active processes** running on the system.

Why It's Useful:

- See which programs are currently executing
- Check **process IDs (PIDs)** and **parent-child relationships**
- Identify **CPU and memory usage** per process
- Useful for **troubleshooting** or verifying background services

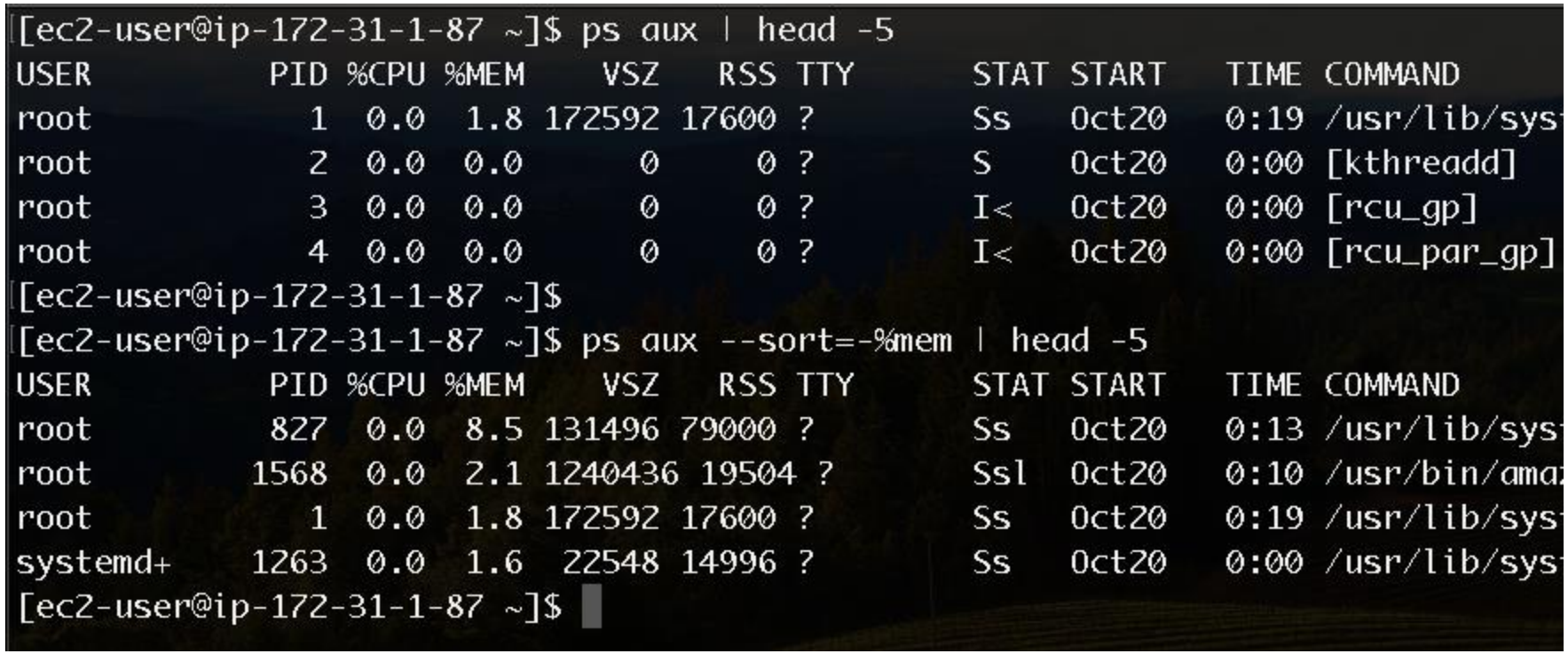
Common Example:

```
ps aux
```

Shows all processes for all users in a detailed list.

💡 *Think of `ps` as a snapshot of what's running at a single moment in time.*

Linux Processes



Linux Processes

Understanding `ps aux` Output
The `ps aux` command lists **all running processes** in a detailed snapshot — similar to `top`, but static.

Key Columns Explained:
- **USER** – Owner of the process
- **PID** – Process ID
- **%CPU / %MEM** – CPU and memory usage percentages
- **VSZ / RSS** – Virtual and resident memory sizes
- **TTY** – Terminal associated with the process (if any)
- **STAT** – Process state (e.g., R = running, S = sleeping, Z = zombie)
- **START** – When the process began
- **TIME** – Total CPU time used
- **COMMAND** – The program or command that started the process

💡 *`ps aux` provides a quick snapshot of system activity — while `top` continuously updates in real time.*

Linux Processes

Every process on a Linux system is **started by another process** — its **parent**.
The relationship is tracked using **PIDs** and **PPIDs** (Parent Process IDs).

Example:
`ps -ef`

Common columns:

- **UID** – User who started the process
- **PID** – Process ID
- **PPID** – Parent Process ID
- **CMD** – Command that launched the process

Concept:

- The **parent process** creates a **child process** using the `fork()` system call.
- When a **parent process ends**, its children either receive a `SIGHUP` signal and terminate (if attached to the same terminal), or become ***orphans*** that are automatically adopted by `systemd` (PID 1).

💡 *Understanding parent-child relationships helps trace where a process came from and how it was started.*

Finding and Managing Processes

To locate specific processes, you can **search process lists** using `ps` and `grep`:

```
ps -ef | grep stress
```

If you only need the **Process ID (PID):**

```
pgrep sleep # prints every PID matching sleep
```

Once you have the PID, you can take action:

```
kill <PID>      # Politely ask the process to terminate (SIGTERM)
kill -9 <PID>   # Force kill (SIGKILL) — cannot be ignored
```

You can also use the `pkill` command to kill any process that has sleep in it.

```
pkill -9 stress # Force kills all processes with "stress" in the name
```

💡 *Use `-9` only if the process doesn't respond to a normal `kill` — it bypasses cleanup routines.*

Checking System Resource Usage

`df` – Disk Free Space

```
df -h
```

Shows available and used disk space for all mounted file systems.
(*`-h` = human-readable sizes like GB, MB)*

`du` – Disk Usage

```
du -h ~
```

Displays how much space a file or directory uses.

`free` – Memory Usage

```
free -h
```

Shows total, used, and available system memory and swap space.

💡 *These commands help you quickly assess disk and memory usage when troubleshooting or monitoring system health.*

Finding System Information

To learn more about your system, start with the **`uname`** command:

```
uname -a
```

Displays **all system information**, including kernel name, version, release, architecture, and hostname.

Other useful `uname` options:

- `uname -s` → Kernel name
- `uname -r` → Kernel release
- `uname -m` → Machine hardware (architecture)
- `uname -n` → System hostname

💡 *Use `man uname` to view the manual and explore all available options.*

You can also check system details with:

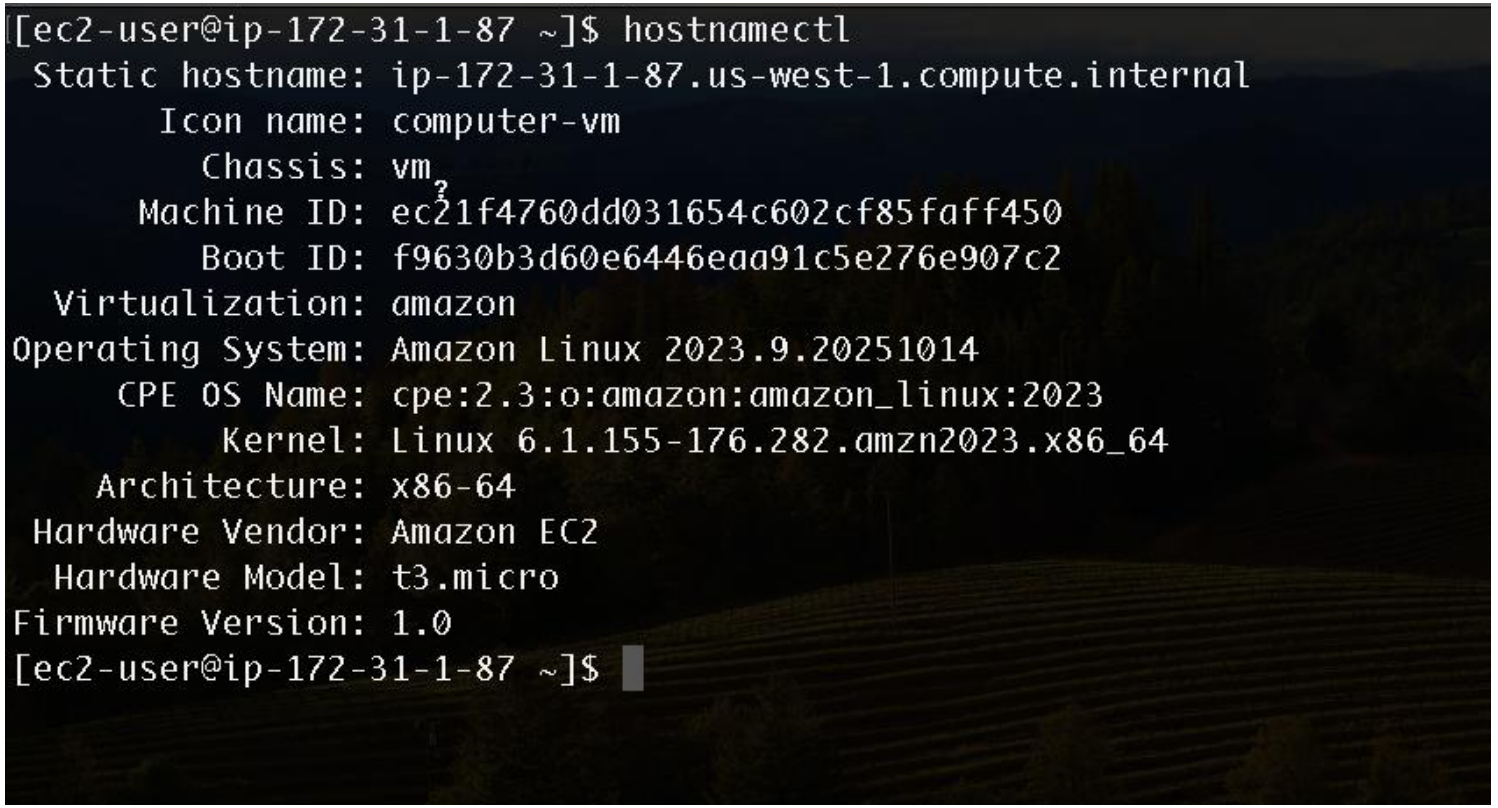
```
hostnamectl     # System name, OS, and kernel info
```

Finding System Information

System Information details are essential when **installing software**, **compiling source code**, or **downloading the correct package version**.

It also helps with **troubleshooting**, ensuring commands, drivers, and binaries match your system's environment.

💡 *Knowing your system's architecture and kernel saves time and prevents compatibility issues.*



Useful System Commands

`lscpu`
Displays detailed information about the CPU architecture, including cores, threads, and virtualization support.
```
lscpu
```

`uptime`
Shows how long the system has been running, the number of users, and the load average.
```
uptime
```

`iostat`
Reports CPU utilization and disk I/O statistics, useful for performance analysis.
```
iostat
```

`vmstat`
Provides a snapshot of system performance, showing processes, memory, paging, block I/O, and CPU usage.
```
vmstat
```

💡 *These tools help you understand how the system is performing under different workloads.*

User Login and Session Commands

`who`
Shows who is currently logged in and where they're connected from.
```
who
```

`w`
Displays logged-in users plus what each user is currently doing.
```
w
```

`last`
Lists the login history, including previous users, login times, and session durations.
```
last
```

💡 *These commands help track active sessions, monitor user activity, and review login history for auditing or troubleshooting.*

Network Monitoring

The `ss` Command (Socket Statistics)

What It Is:
ss is a **modern replacement for `netstat`** — faster, built into most Linux distributions, and part of the core system utilities.

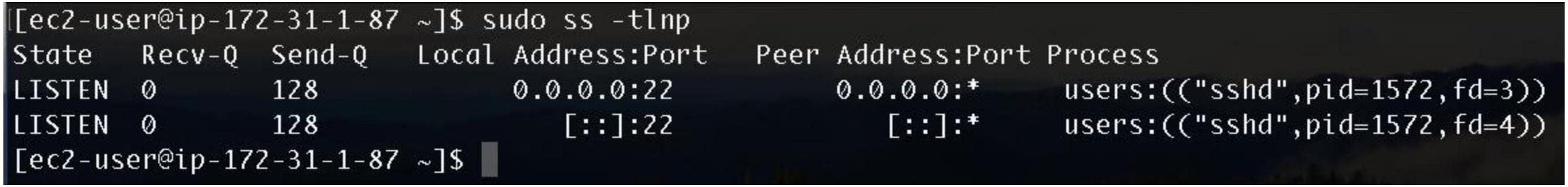
Common Uses:

```
ss -tuln     # Show TCP/UDP listening ports
ss -tp       # Show active TCP connections with process info
```

Why It's Useful:

- Verify that **services are listening** on the correct ports
- Check **active connections** and who's connecting
- Helpful for **network troubleshooting** and **security checks**

💡 *`ss` gives you a clear, real-time view of network sockets — essential for validating running services.*



Network Monitoring

Network Interfaces and IP Information

Every system administrator must know how to view **network interfaces, IP addresses,** and **routing information**.
The **`ip`** command provides all of this in one place:

```
ip addr show        # Display IP addresses and interfaces
ip link show        # Show network interfaces and their states
ip route show       # View routing table information
```

💡 *The `ip` command replaces older tools like `ifconfig` and `route` — it's the modern standard for network management.*

Command	Layer	Shows	Connected To
`ip link show`	2 (Data Link)	Interfaces, MACs, state	Switch port
`ip addr show`	3 (Network)	IPs, subnets, broadcast	Logical network info
`ip route show`	3 (Network)	Routing table	Path decisions

Network Monitoring

When you run:
`ip address show`

you'll see something like:
`inet 192.168.1.10/24 brd 192.168.1.255 scope global eth0`

Here's what that means:

- `192.168.1.10` → your **IP address**
- `/24` → the **CIDR notation** (Classless Inter-Domain Routing) — tells you the **subnet mask**
- `/24` translates to `255.255.255.0`, which means:
- The first **24 bits** represent the **network portion**
- The remaining **8 bits** are for **hosts**
- `192.168.1.255` → Broadcast Address

The CIDR suffix (`/24`, `/16`, `/20`, etc.) tells you **how large your subnet is** and **which range of IPs belong to your network**.

💡 CIDR = *the size and boundaries of your network.*

Network Monitoring

🧭 Understanding `ip route show`

Example output:

```
default via 192.168.1.1 dev eth0
192.168.1.0/24 dev eth0 proto kernel scope link src 192.168.1.10
```

Let's decode it:

- **`default via 192.168.1.1 dev eth0`**
- The **default route** is used when no other route matches.
- `via 192.168.1.1` → the **gateway or router** the system sends unknown traffic to (usually your router).
- `dev eth0` → the **network interface** used to reach it.

- **`192.168.1.0/24 dev eth0`**
- This is your **local network route**.
- `/24` → subnet mask 255.255.255.0
- `dev eth0` → packets to this subnet stay **within the LAN** (no gateway needed, uses the switches).
- `src 192.168.1.10` → the **source IP** your system uses for this network.

💡 **In short:**

- `default` = route for *everything else* (internet, other networks)
- CIDR routes (like `192.168.1.0/24`) = *local subnets* your system directly knows about

System Logs

Recent Kernel Messages

```
sudo dmesg | tail -20
```

Shows the **last 20 messages from the kernel**, such as hardware events or driver activity.

Recent System Logs

```
sudo journalctl -n 20 --no-pager
```

Displays the **last 20 log entries** collected by the **systemd journal**.

journalctl is the **go-to command for viewing logs** from services, the kernel, and system events — all in one place.

💡 *Use these commands to quickly check system health and recent activity without digging through log files.*

Lab 1.0 System Monitoring

Estimated Time: 35 Minutes

POP QUIZ:

What command will print every process with common headers to standard output?

A. pt --all
B. top
C. ps
D. ps aux

POP QUIZ:

What non-interactive command will print every process with common headers to standard output?

A. pt --all
B. top
C. ps
D. ps aux

"What does ps without options do?"

POP QUIZ:

How can I view the size of every file in a directory?

A. du -h /path
B. df -h /path
C. sizeof /path
D. free /path

POP QUIZ:

How can I view the size of every file in a directory?

A. du -h /path
B. df -h /path
C. sizeof /path
D. free /path

"What is the difference between du and df?"

POP QUIZ:

Which commands can I use to find the correct architecture type of my system?

A. uname -a
B. vmstat
C. lscpu
D. hostnamectl

POP QUIZ:

Which commands can I use to find the correct architecture type of my system?

A. uname -a
B. vmstat
C. lscpu
D. hostnamectl

"What does vmstat do again?"

POP QUIZ:

Which is the go-to tool for viewing logs on your OS?

A. /var/log
B. dmesg
C. journalctl
D. who

POP QUIZ:

Which is the go-to tool for viewing logs on your OS?

A. /var/log
B. dmesg
C. journalctl
D. who

"What is the difference between these commands?"

POP QUIZ:

What command will show the TCP services that are listening and what ports they are bound do?

A. sudo ss -tlnp
B. ip services show
C. ss -ulnp
D. ip link show

POP QUIZ:

What command will show the TCP services that are listening and what ports they are bound do?

A. sudo ss -tlnp
B. ip services show
C. ss -ulnp
D. ip link show

"What do the -tlnp options do?"

POP QUIZ:

What command can show the range of ips in your network interface?

A. ip link show
B. ip address show
C. ip route show
D. all of the above

POP QUIZ:

What command can show the range of ips in your network interface?

A. ip link show
B. ip address show
C. ip route show
D. all of the above

"What do the other commands show?"

Linux: Jobs

Jobs in Linux represent the tasks your system is currently running — whether in the foreground, background, or paused. Understanding how to manage jobs gives you control over your workload without restarting commands or opening new terminals.

A skilled admin knows how to suspend, resume, and terminate jobs as needed. It's not just about multitasking; it's about efficiency. Mastering job control means you can manage processes confidently, stay organized, and keep the system responsive while you work.

Linux: Jobs

Any task running in Linux is considered a **job**.

A job running in the **foreground** uses your terminal and **blocks other commands** until it finishes.

A job running in the **background** allows **multiple tasks** to run simultaneously without interrupting your terminal.

💡 *Foreground jobs demand your attention — background jobs let you multitask.*

Linux: Jobs

Start in the **background**:

```
sleep 100 &
```

Pause a **foreground** job (sends **SIGTSTP**):

```
sleep 200
# Press: Ctrl + Z
```

List jobs:

```
jobs
```

Resume the most recent *stopped* job in the background (sends **SIGCONT**):

```
bg %+
```

(Optional) Bring the most recent job to the foreground:

```
fg %+
```

💡 *`Ctrl+Z` = SIGTSTP (stop). `bg` = SIGCONT (resume in background). `fg` resumes in foreground.*

Linux: Referencing and Managing Jobs

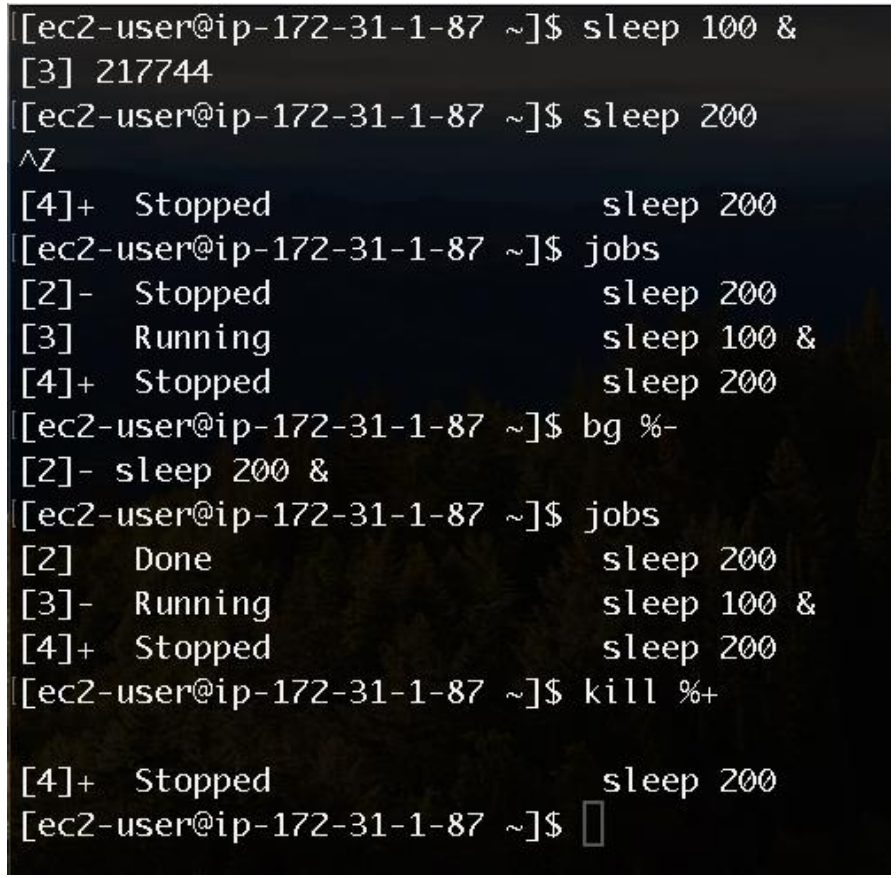
You can reference jobs using **job symbols** instead of PIDs:

- `%+` → Most recent job
- `%-` → Second most recent job
- `%3` → Specific job number (from `jobs` output)

You can **terminate a job** using either its **PID** or its **job symbol**:

```
kill %+      # Kill most recent job
kill %-      # Kill second most recent
kill %3      # Kill job number 3
```

💡 *Job symbols make it easy to manage background tasks without remembering PIDs.*



Linux: kill command

The `kill` command isn't just for ending processes — it's used to **send signals** to them.

You can list all available signals with:

```
kill -l
Kill -19 $PID # sends SIGTOP to pause a process
```

Common Signals:

- **SIGTERM (15)** – Politely asks a process to terminate (default signal).
- **SIGKILL (9)** – Forcefully stops a process immediately (cannot be ignored).
- **SIGINT (2)** – Interrupts a process (like pressing **Ctrl+C**).
- **SIGHUP (1)** – Sent when a terminal disconnects; often used to reload configs.
- **SIGSTOP (19)** – Pauses a process (cannot be caught or ignored).
- **SIGCONT (18)** – Resumes a paused process.

💡 *Think of `kill` as a way to **communicate** with processes — not always to destroy them.*

Linux: No Hanging Up

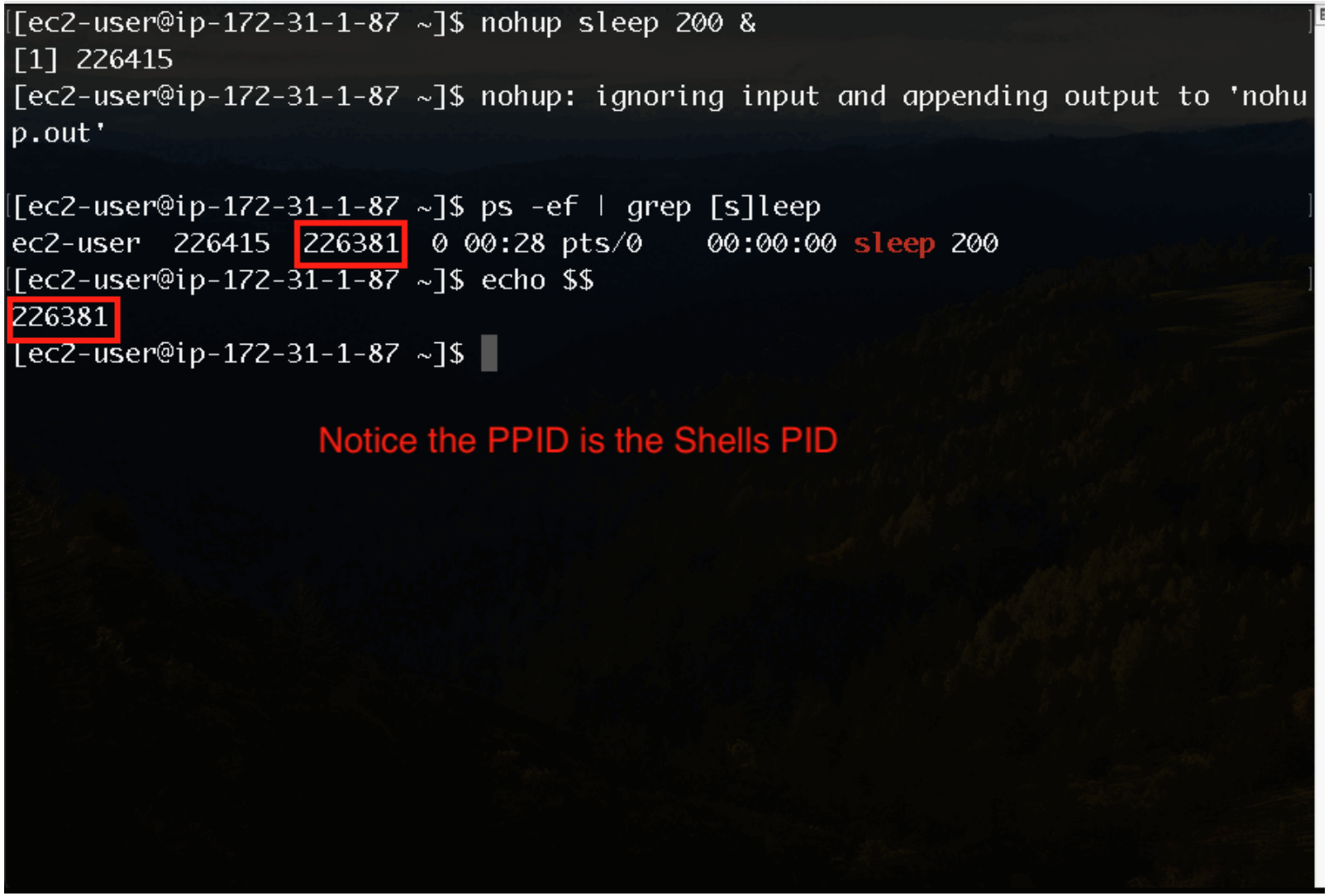
The `nohup` command keeps a process running **even if the terminal is closed or disconnected**.

It prevents the kernel from sending the **SIGHUP (hangup)** signal when the **parent process** (your shell) terminates.

This is particularly useful for **long-running tasks** — like database updates or backups — that might otherwise stop if your SSH session ends.

When the parent shell exits, the process becomes an **orphan**, which is then **adopted by `systemd`** (or **`init`** on older systems), changing its **PPID to 1**.

Linux: nohup demo (gif)



Lab 2.3 Linux Jobs

Estimated Time: 20 Minutes

POP QUIZ:

How can a job run in the background?

A. add ! to end of command
B. Ctrl+C
C. add & to end of command
D. Piping the command to nohup

POP QUIZ:

How can a job run in the background?

A. add ! to end of command
B. Ctrl+C
C. add & to end of command
D. Piping the command to nohup

"How else can we send a job to background?"

POP QUIZ:

A process refuses to terminate, how can we force it to terminate?

A. Kill -9
B. Kill -19
C. nohup
D. bg

POP QUIZ:

A process refuses to terminate, how can we force it to terminate?

A. Kill -9
B. Kill -19
C. nohup
D. bg

"What does kill –19 do?"

POP QUIZ:

How can the most recent job be started?

A. jobs start recent
B. fg %-
C. bg %-
D. bg %+

POP QUIZ:

How can the most recent job be started?

A. jobs start recent
B. fg %-
C. bg %-
D. bg %+

"What is %- for?"

Linux: Operators

Linux operators are the **symbols that control how commands interact** — they connect, redirect, and manage the flow of information between processes. Understanding them transforms single commands into powerful workflows.

A skilled admin uses operators to **chain tasks, redirect input and output, and handle errors gracefully**. It's not just about running commands; it's about precision and automation. Mastering operators means you can build efficient, reliable command sequences that do exactly what you intend.

Linux: Logical Operators

The special variable **`$?`** stores the **exit code** of the **most recently executed command**.

- A value of **`0`** indicates **success**.
- Any **non-zero** value indicates **failure** — the meaning of each code depends on the command (see the **manual** for details).

Example:

```
echo hello
echo $? # will echo "0" indicating success
0
```

Why It Matters:

Logical operators `&&` and **`||`** use the exit code to decide what happens next:

- `cmd1 && cmd2` → run `cmd2` **only if** `cmd1` **succeeds**
- `cmd1 || cmd2` → run `cmd2` **only if** `cmd1` **fails**

💡 *Exit codes are how Linux commands "communicate" success or failure to each other.*

Linux: Logical Operators

Examples:

```
echo hello && echo "Success" || echo "Failure"
```

✅ Both `echo` commands succeed → prints *hello* and *Success*

```
echo hello && ech "Success" || echo "Failure"
```

(`ech` is misspelled → fails)
➡️ prints hello and Failure, since the second command returned a non-zero exit code.

```
false || echo "This runs because 'false' failed"
```

➡️ `false` always returns failure → triggers the command after `||`.

```
ech hello ; echo world
```

➡️ The semicolon **`;`** always runs the next command — success or failure doesn't matter. World will be printed after the error.

💡 *&& = run next if success || = run next if failure ; = always run next*

Linux: Logical Operators

`||` lets you run a fallback command when the previous one **fails**.

This is useful for detecting errors and responding immediately.

```
curl some-endpoint.com || echo "some-endpoint.com not available"
```

If you want to **stop the script** when a command fails, use a block with `exit 1`:

```
curl some-endpoint.com || { echo "Endpoint not available"; exit 1; }
```

💡 *`||` can provide simple error messages or stop execution entirely when something goes wrong.*

Linux: File Descriptors and Redirection

Every Linux process uses **three standard file descriptors**:

- **0 – stdin** (standard input)
- **1 – stdout** (standard output)
- **2 – stderr** (standard error)

Redirecting Output:

```
echo "hello world" > myfile
echo "hello again" > myfile
cat myfile
```

➡️ > writes (overwrites) output to a file.
You can also write explicitly with 1> — it's the default for stdout.

Appending Output:

```
echo "new line" >> myfile
```

➡️ >> appends instead of overwriting.

Linux: Redirecting Standard Error (stderr)

Standard error uses **file descriptor 2**, separate from standard output.

```
ls /fakefolder 2> errors.log
```

➡️ The error message is **redirected** to `errors.log` instead of the screen.

```
ls /etc 2> errors.log
```

➡️ No error here — the output still prints to the screen (stdout), and `errors.log` remains **empty**.

```
ls /fakefolder > output.log
```

❌ Command fails → error message still prints to screen.
output.log is **empty** because there was no standard output.

💡 *2> only captures **errors** — normal output still goes to the terminal.*

Linux: File Descriptors and Redirection

Redirecting Both stdout and stderr

You can redirect **standard output (1)** and **standard error (2)** separately:

```
command 1> out.txt 2> error.txt
```

➡️ Output goes to **out.txt**
➡️ **Errors go to error.txt**

To redirect **both** to the same file:

```
command > all.txt 2>&1
```

➡️ > redirects stdout to **all.txt**
➡️ 2>&1 sends stderr (2) **to the same place as** stdout (1)

💡 **The & means "use the file descriptor, not a file name."**

Thus 2>&1 means "send errors where standard output is currently going."

Linux: Ignoring Errors Gracefully

Sometimes you don’t care if a command fails — or you just want to hide its errors.

```
command 2> /dev/null || true
```

`2> /dev/null` discards **error messages**
`|| true` forces the command to **succeed** even if it fails

`/dev/null` is a **special device** that discards everything written to it — like a *black hole* for output you don’t care about.

`|| true` is useful when **`set -e`** is enabled (covered later), so one failure doesn’t stop the entire script.

💡 *Use with caution — this hides problems you might later need to debug.*

Linux: Input Redirection

Symbol	Name	Description
`<`	**Input redirection**	Takes input **from a file** instead of the keyboard. Example: `cat < file.txt`

`<<`	**Here Document (heredoc)**	Passes a **block of text** to a command as input until a delimiter.
		Example:
		`cat << EOF`
		`Hello`
		`EOF`

`<<<`	**Here String**	Sends a **single line/string** to a command as input. Example: `cat <<< "Hello world"`

💡 <, <<, and <<< are all forms of **input redirection.** They feed data *into* commands through **stdin (file descriptor 0)** instead of you typing it interactively.

Linux: Input Redirection

```
[ec2-user@ip-172-31-1-87 ~]$ cat math.txt
5+5
10*100
4+4
[ec2-user@ip-172-31-1-87 ~]$ bc < math.txt # inputs the file into bc
10
1000
8
[ec2-user@ip-172-31-1-87 ~]$ bc << EOF # builds a doc for input until EOF
> 10+10
> 4+4
> EOF
20
8
[ec2-user@ip-172-31-1-87 ~]$ bc <<< 5*5 # inputs the string into bc
25
[ec2-user@ip-172-31-1-87 ~]$ cat << EOF > data.txt
> 10, 20, 30
> 40, 50, 60
> EOF
[ec2-user@ip-172-31-1-87 ~]$ cat data.txt
10, 20, 30
40, 50, 60
[ec2-user@ip-172-31-1-87 ~]$
```

Linux: The Pipe Operator (|)

The **pipe (|)** sends the **output** of one command into the **input** of another, allowing multiple commands to work together efficiently.

Basic Examples:

```
ls | grep "log"   # Shows only files containing “log”.
ps aux | grep ssh # Filters running processes for “ssh”
```

Advanced Example (Multiple Pipes + Redirection):

```
cat /var/log/syslog | grep error | wc -l > error_count.txt || echo "Log check failed"
```

💡 *You can chain multiple pipes, redirect outputs, and even handle failures — all in one line.*

Lab 2.4 Operators

Estimated Time: 20 Minutes

POP QUIZ:

What will the following command output?

```
ls | grep txt 2> /dev/null
```

A. nothing
B. All files with txt in its name
C. error
D. grep txt

POP QUIZ:

What will the following command output?

```
ls | grep txt 2> /dev/null
```

"Why does it output even with 2> ?"

A. nothing
B. All files with txt in its name
C. error
D. grep txt

POP QUIZ:

What will the following command output?

```
echo "hello" 1> hello.txt && echo "hello"
```

A. hello hello
B. hello 1> hello.txt hello
C. error
D. hello

POP QUIZ:

What will the following command output?

```
echo "hello" 1> hello.txt && echo "hello"
```

A. hello hello
B. hello 1> hello.txt hello
C. error
D. hello

"Which echo output to stdout ?"

POP QUIZ:

What will the following command output?

```
echo "hello world" 2> /dev/null || echo "fail"
```

A. hello world
B. hello 1> hello.txt hello
C. error
D. hello

POP QUIZ:

What will the following command output?

```
echo "hello world" 2> /dev/null || echo "fail"
```

"What is the purpose of /dev/null ?"

A. hello world
B. hello 1> hello.txt hello
C. error
D. hello

POP QUIZ:

What command will count how many lines are in a file?

A. grep -c myfile.txt
B. linecount myfile.txt
C. wc -l < myfile.txt
D. myfile.txt | wc -l

POP QUIZ:

What command will count how many lines are in a file?

A. grep -c myfile.txt
B. linecount myfile.txt
C. wc -l < myfile.txt
D. myfile.txt | wc -l

"How can we make A. and D. work?"

Lab 2.5 Monitoring Challenge

Estimated Time: 60 Minutes

Linux Day 2 Complete

🎉 Great Work Today!

Today you learned how to:

- Edit and manage files using **Vim**
- Monitor system performance and processes
- Control and manage **Linux jobs**
- Use **operators** to connect, automate, and handle commands efficiently

Give yourself a pat on the back — you've taken another big step toward becoming an **effective and confident System Administrator**.

💡 *Keep practicing — mastery in Linux comes from curiosity, repetition, and exploration.*