🧠 Linux Process Management — Technical Assignment

A Guided Exploration of How Linux Really Thinks

🔹 1. Enumerating All Active Processes

🔧 Command

```
ps aux
```

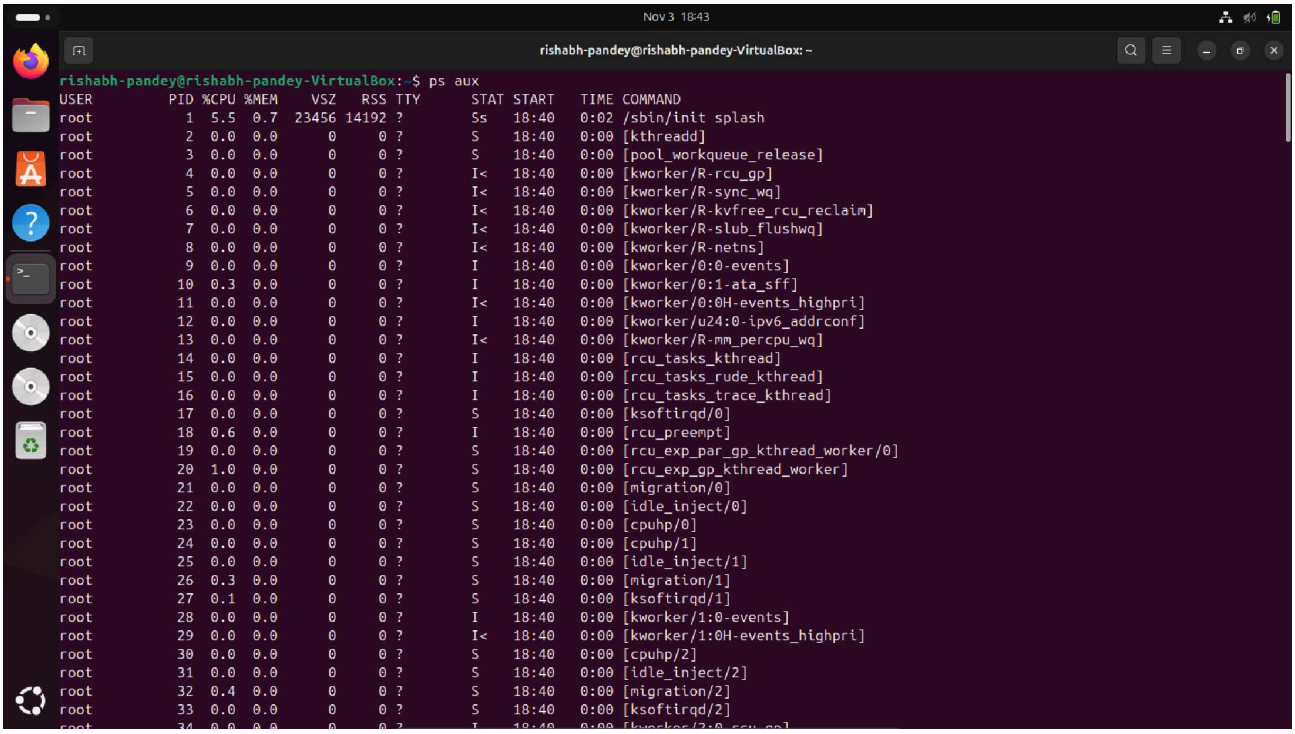
🧩 Conceptual Insight

This classical invocation of `ps` provides a **snapshot of the entire process space**.

- `a` → Display processes of *all* users
- `u` → Include the effective user, CPU%, memory%, etc.
- `x` → Show processes detached from any controlling terminal

Together, they approximate a low-level "process census," useful for diagnostic baselining.

📸 Output



🌲 2. Visualizing the Process Hierarchy

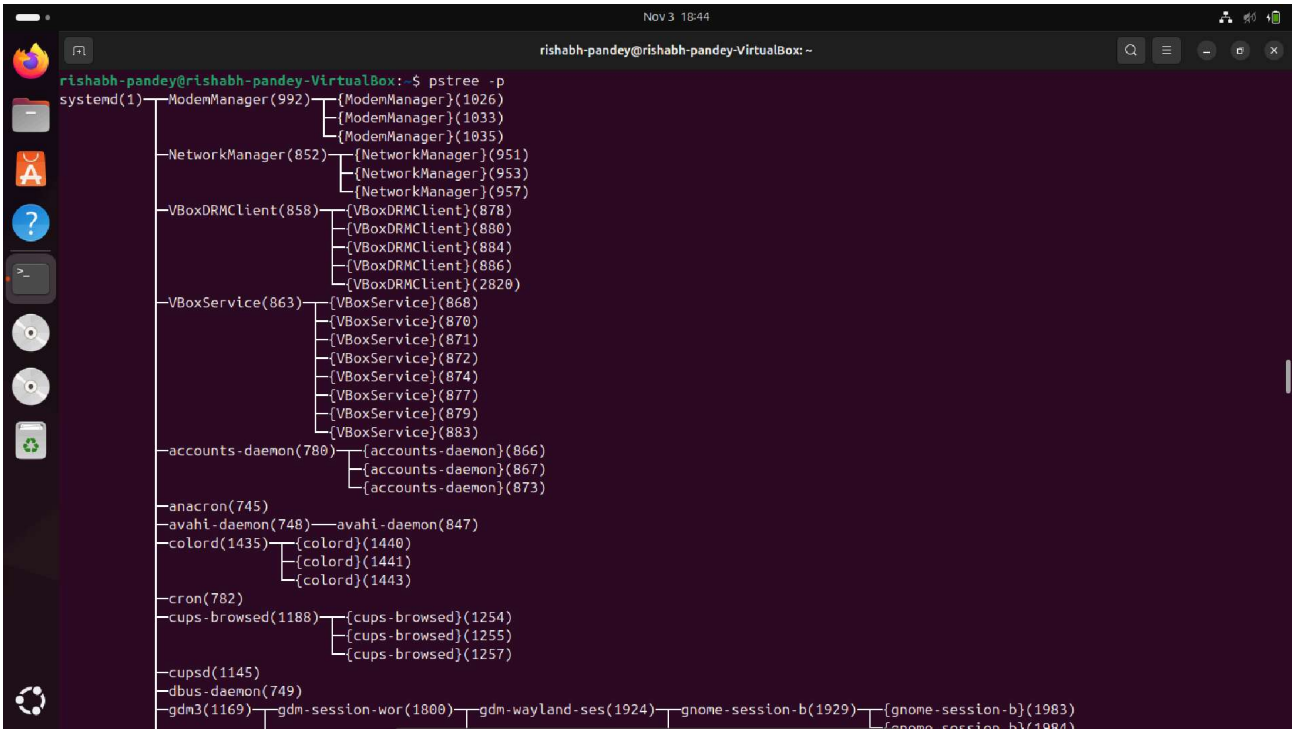
🔧 Command

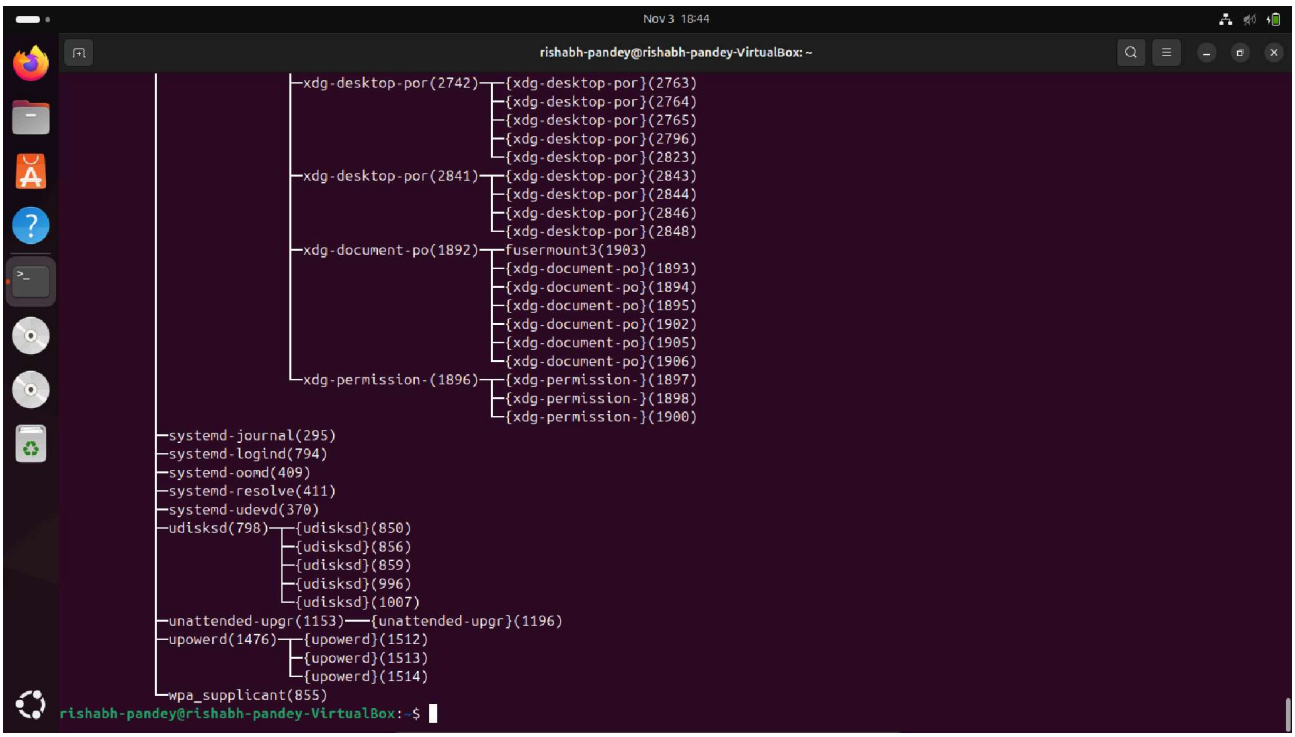
```
pstree -p
```

🧩 Conceptual Insight

Processes in Linux are not a flat list; they form a **hierarchical tree** rooted in `systemd` (or historically, `init`). `pstree` exposes these ancestry relations, making orphaned or runaway children immediately visible.

📸 Output





📊 3. Observing Real-Time System Dynamics

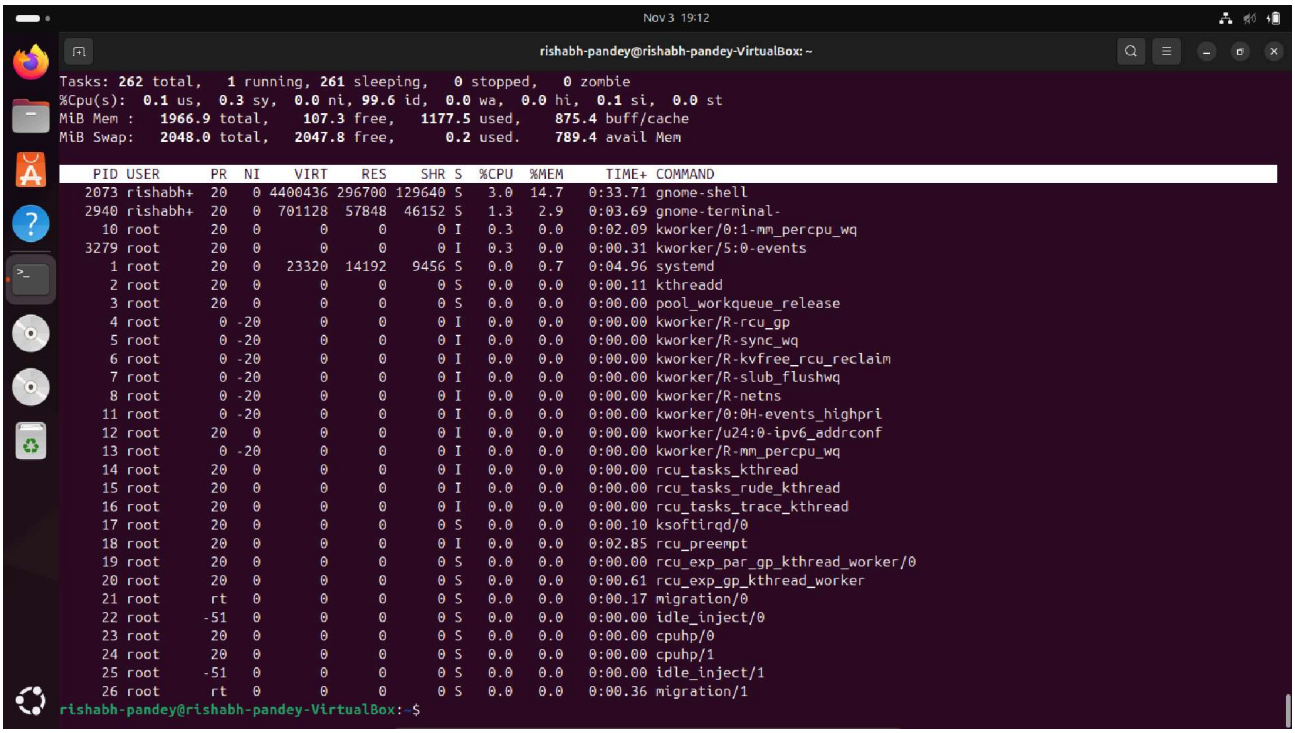
🔧 Command

```
top
```

🧩 Conceptual Insight

`top` acts as a **living cross-section** of process activity — updated continuously. Use it to spot CPU hogs, memory leaks, or load spikes. 👉 Press `q` to exit before losing yourself in the numbers.

📸 Output



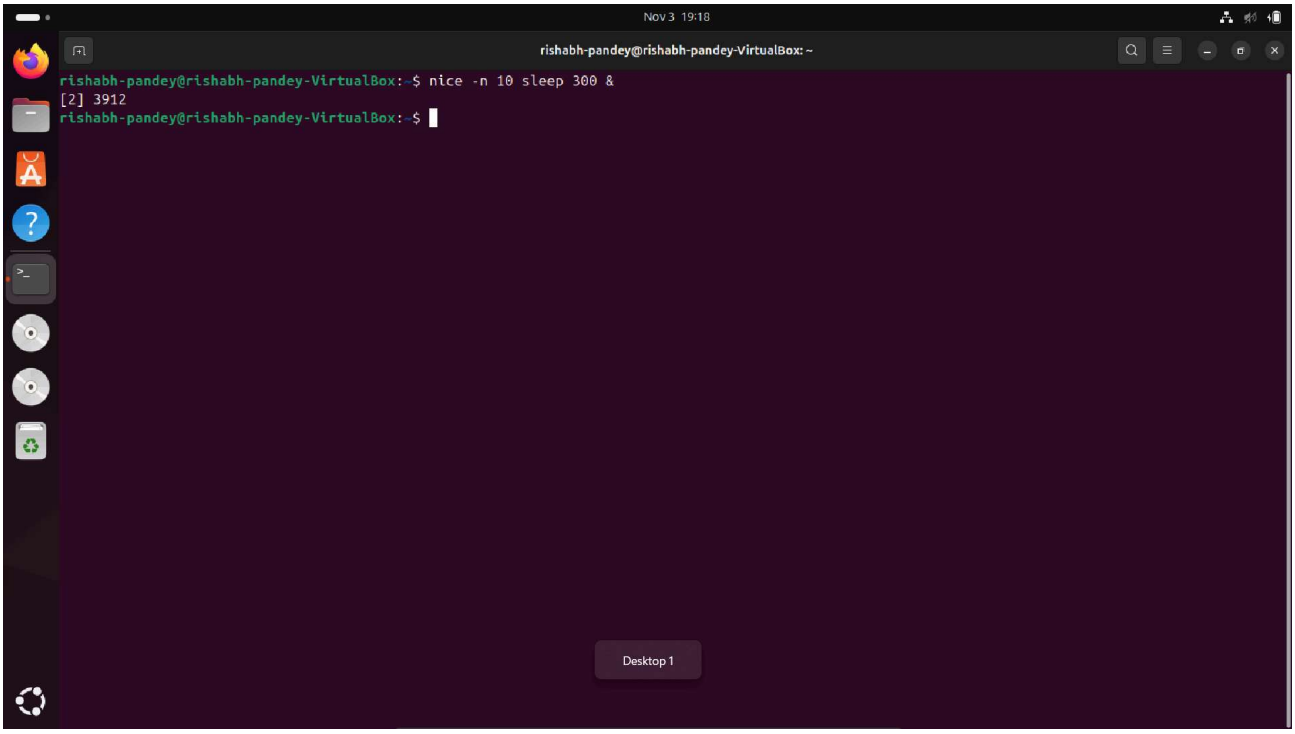
⚡ 4. Manipulating Process Scheduling Priority

🟢 Start a Process at Lower Priority

```
nice -n 10 sleep 300 &
```

👉 Here, the process (PID `3050` assumed) is launched with a *niceness* of `10`, signaling lower scheduling priority.

📸 Output

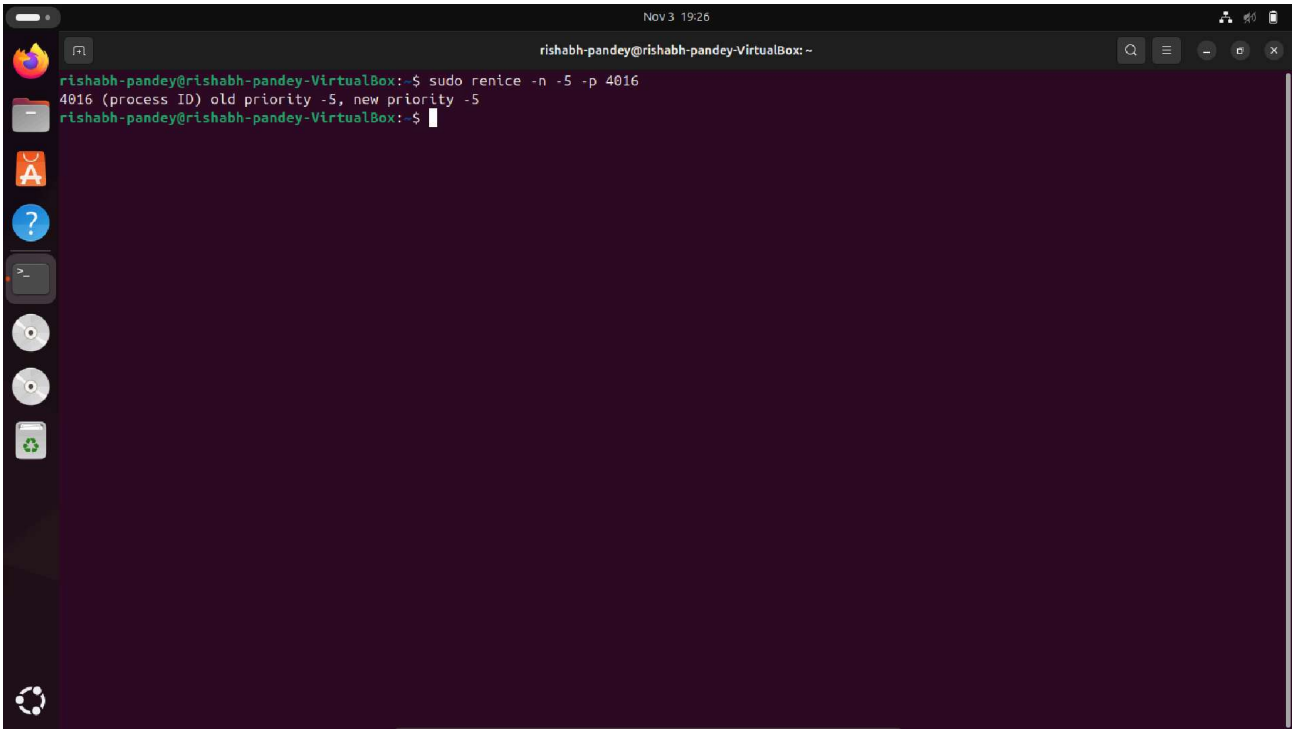


🔄 Reprioritize an Existing Process

```
renice -n -5 -p 3050
```

👉 Increasing priority (negative nice values) lets a process request more CPU attention — though it's still subject to kernel policy constraints.

📸 Output

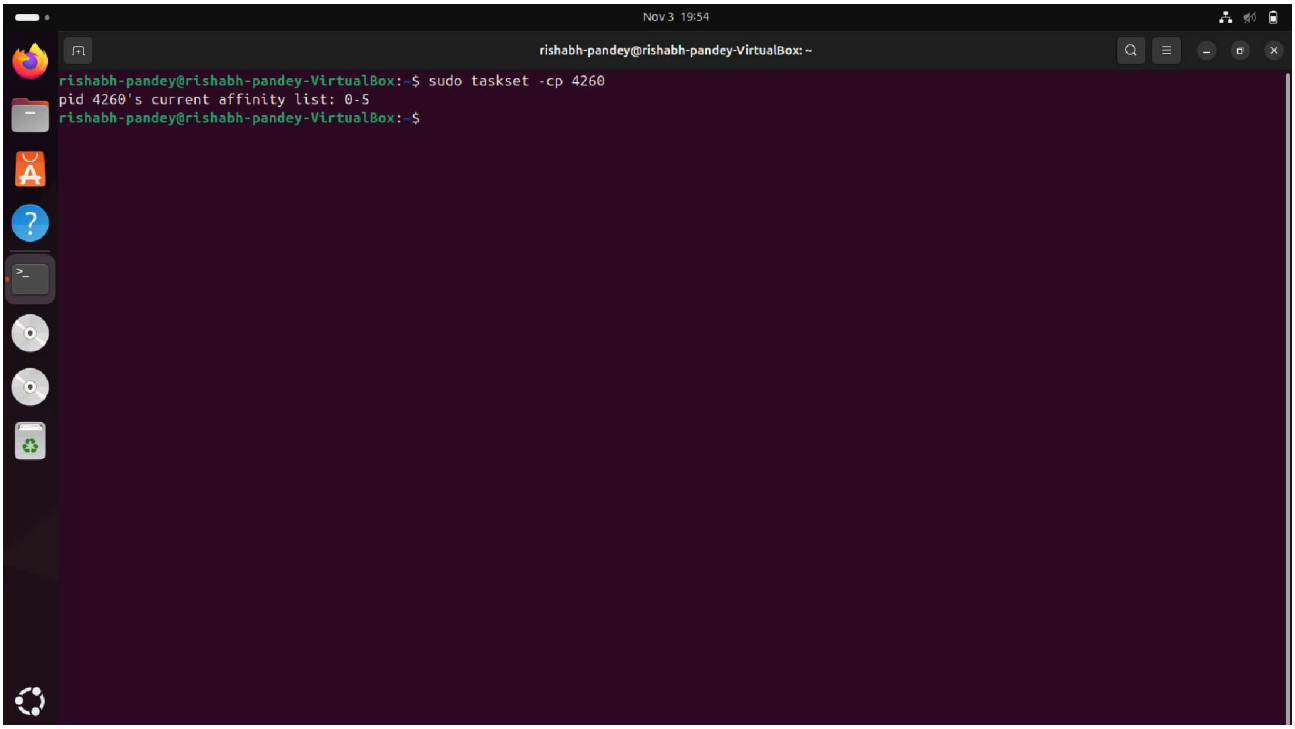


🔧 5. CPU Affinity — Binding a Process to Specific Cores

🔍 Inspect Current CPU Affinity

```
taskset -cp 3050
```

📸 Output

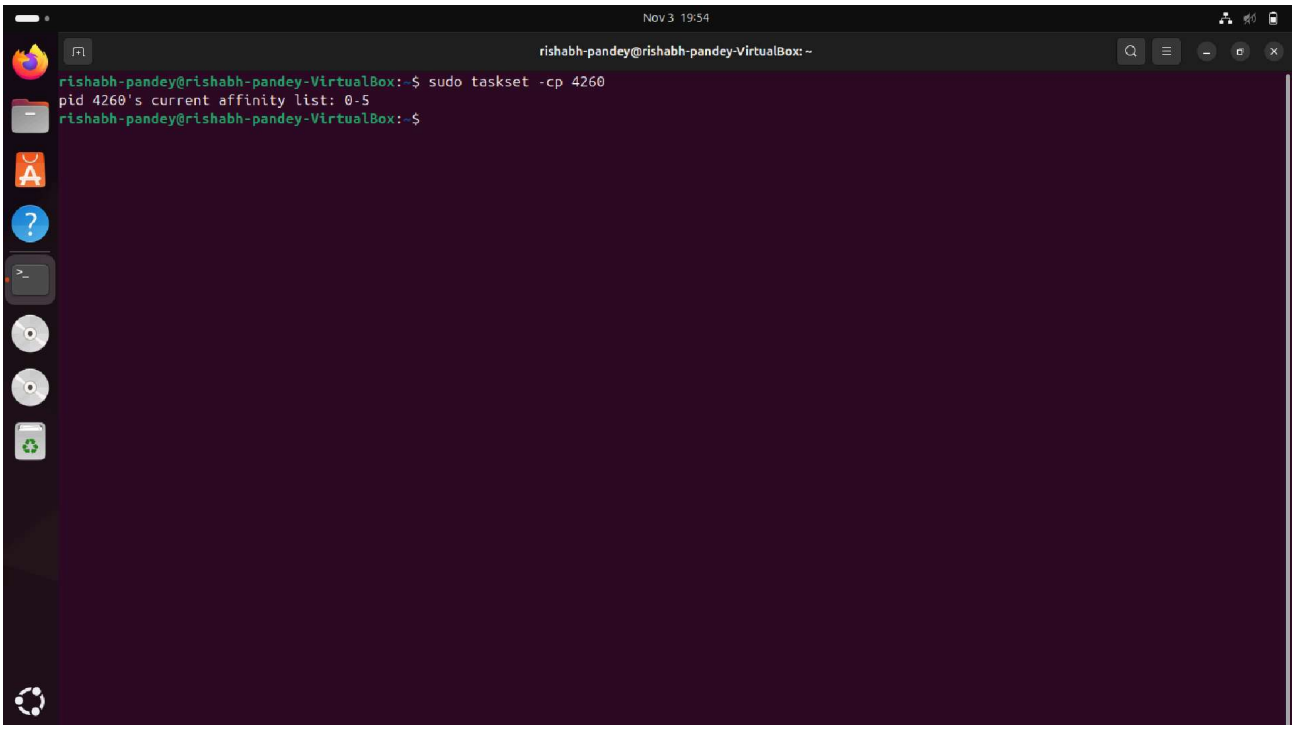


🎯 Bind the Process Strictly to Core 1

```
taskset -cp 1 3050
```

👉 Useful for performance isolation, cache locality experiments, or preventing contention.

📸 Output



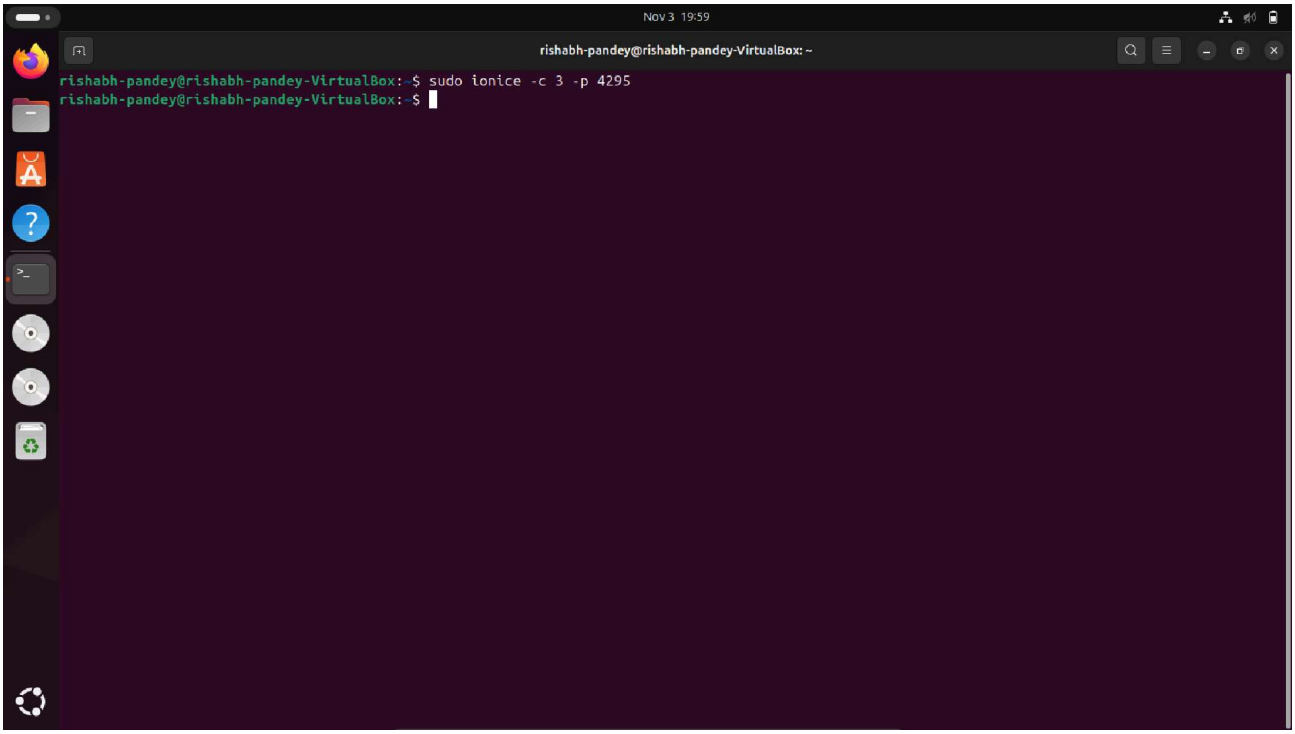
📂 6. I/O Scheduling Priority

🔧 Command

```
ionice -c 3 -p 3050
```

👉 Class `3 (idle)` means the process performs disk I/O *only when the system is otherwise idle* — excellent for background jobs.

📸 Output



📑 7. Inspecting File Descriptors of a Process

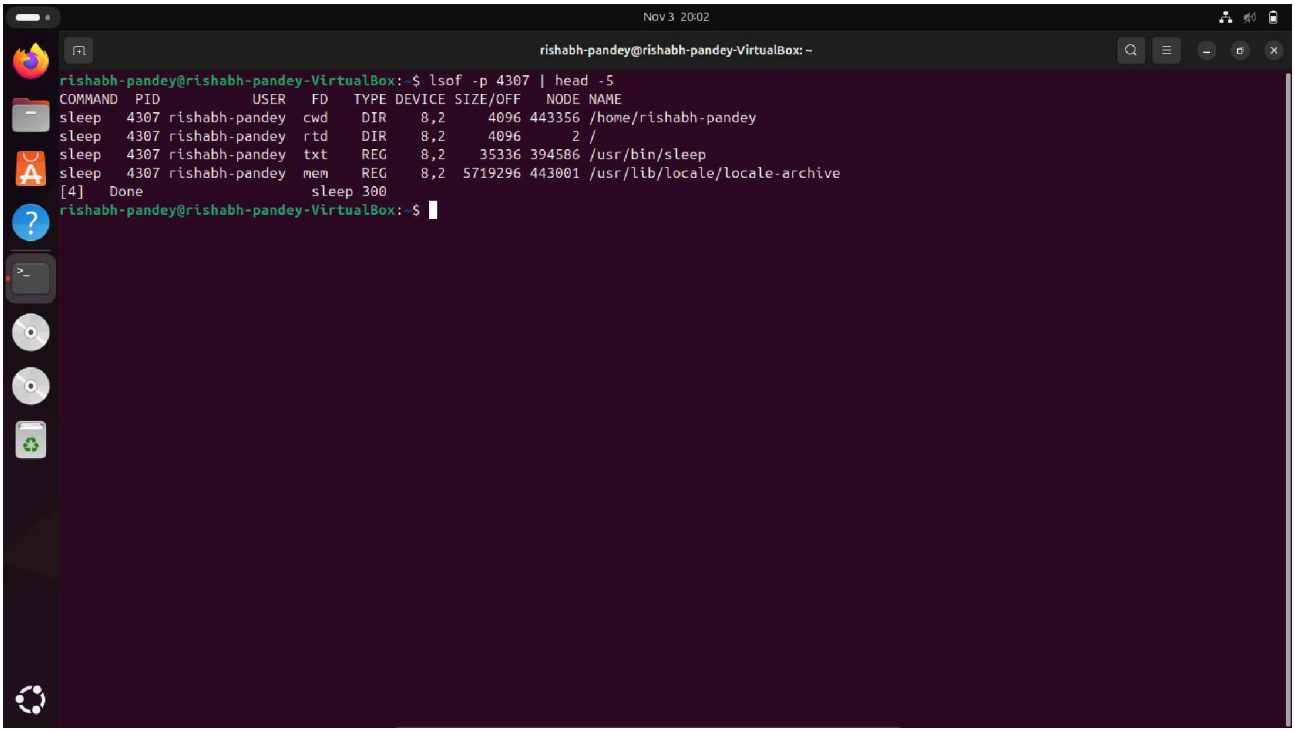
🔧 Command

```
lsof -p 3050 | head -5
```

🧩 Conceptual Insight

A process is fundamentally defined by the **resources it holds**. `lsof` reveals open files, sockets, pipes, and more — invaluable for debugging stuck I/O or memory-leaking daemons.

📸 Output



🐛 8. Tracing System Calls

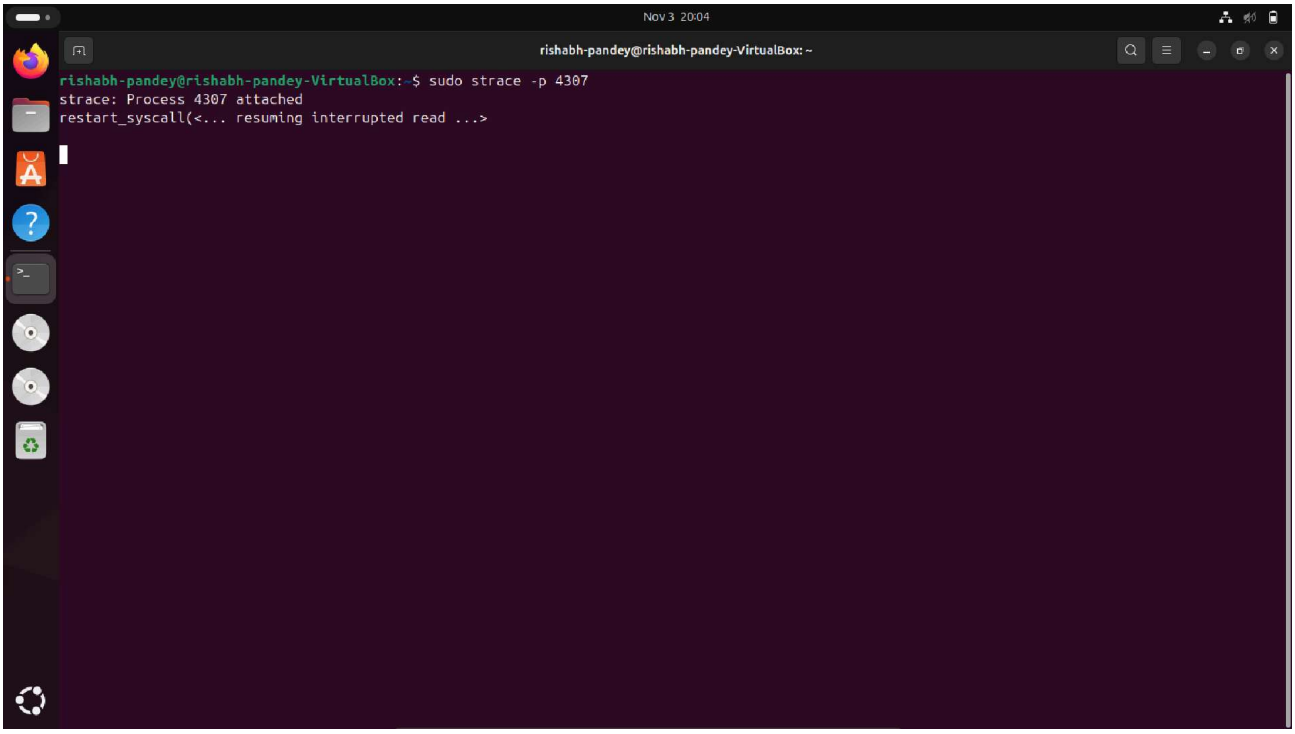
🔧 Command

```
strace -p 3050
```

🧩 Conceptual Insight

This attaches a live syscall-level microscope to the process. Perfect for reverse-engineering behavior, debugging failures, or understanding program–kernel interactions.

📸 Output



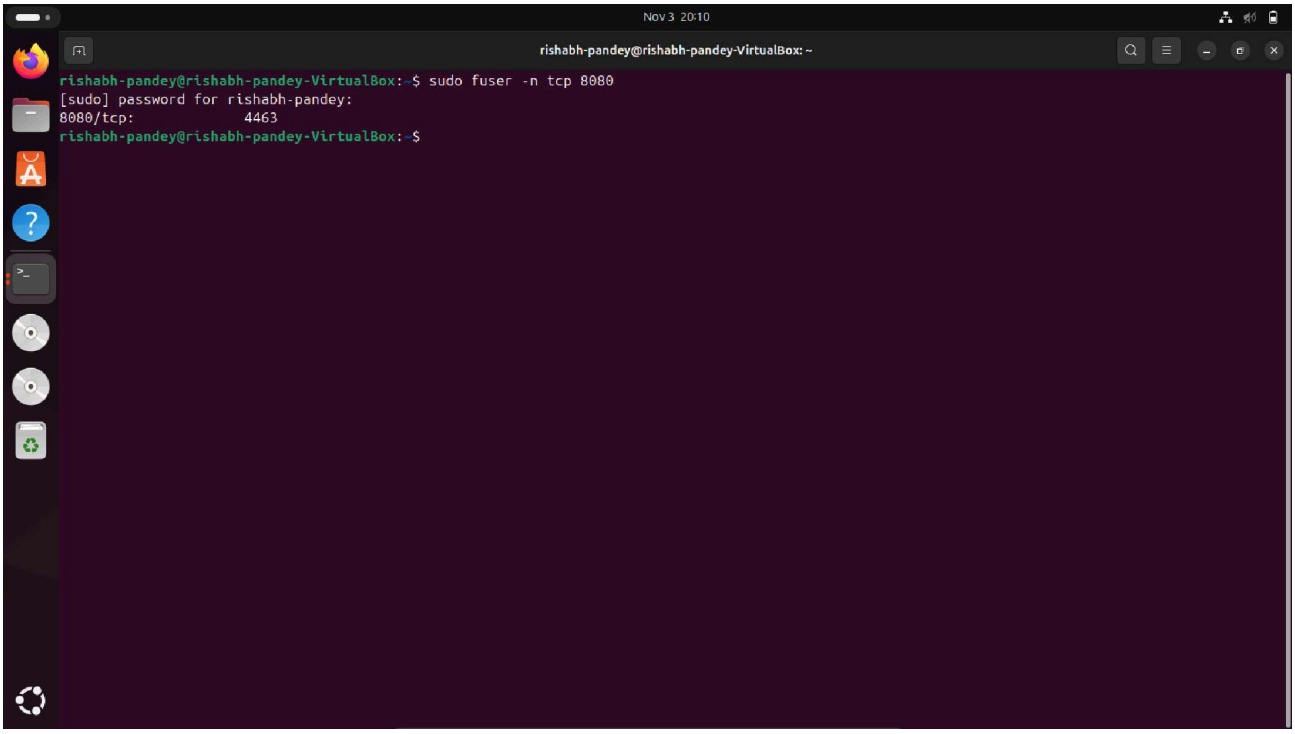
📡 9. Identifying Which Process Owns a Network Port

🔧 Command

```
sudo fuser -n tcp 8080
```

👉 If PID `4321` appears, that's your port consumer — often helpful for debugging services, conflicts, or ghost processes.

📸 Output

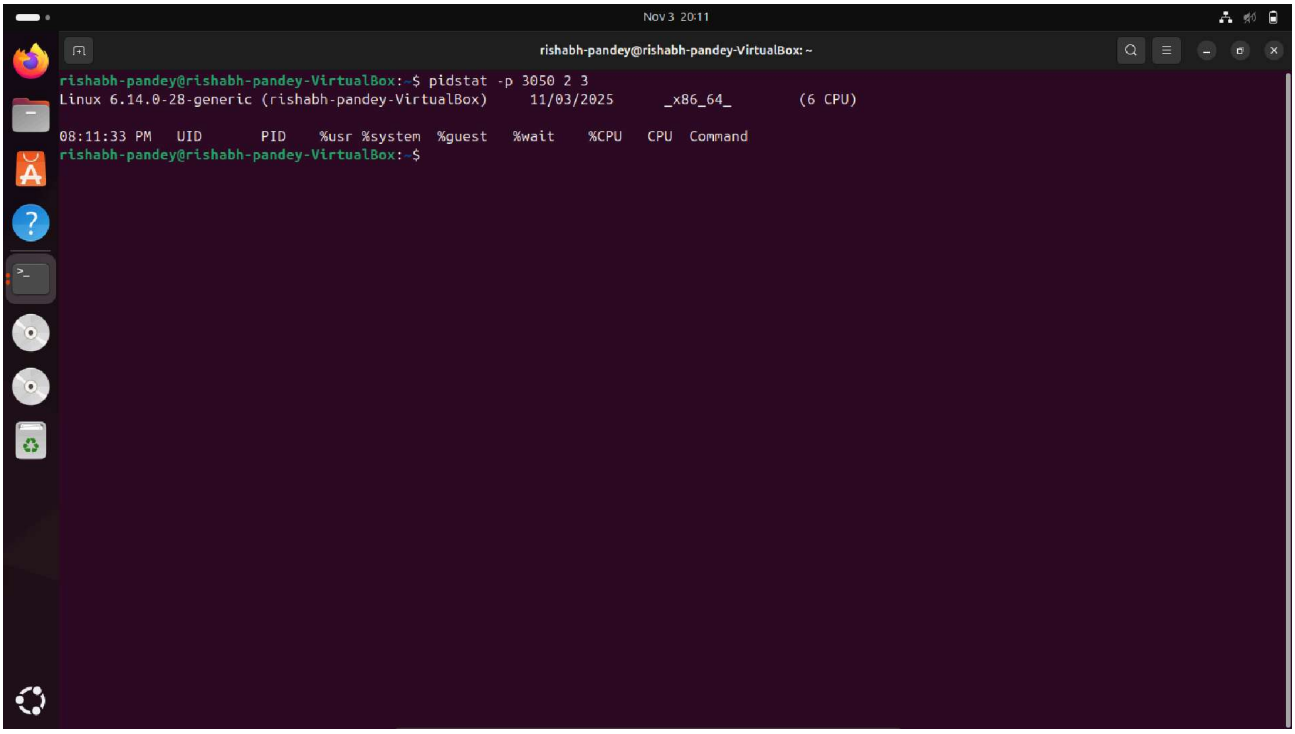


📊 10. Per-Process Performance Statistics

🔧 Command

```
pidstat -p 3050 2 3
```

👉 Samples CPU/IO usage every **2 seconds**, repeating **3 times** — a lightweight profiler without full tracing overhead.



📸 Output

🔐 11. Resource Governance with Control Groups (cgroups)

🛠️ Create a Dedicated cgroup

```
sudo cgcreate -g cpu,memory:/testgroup
```

🚦 Apply Resource Limits

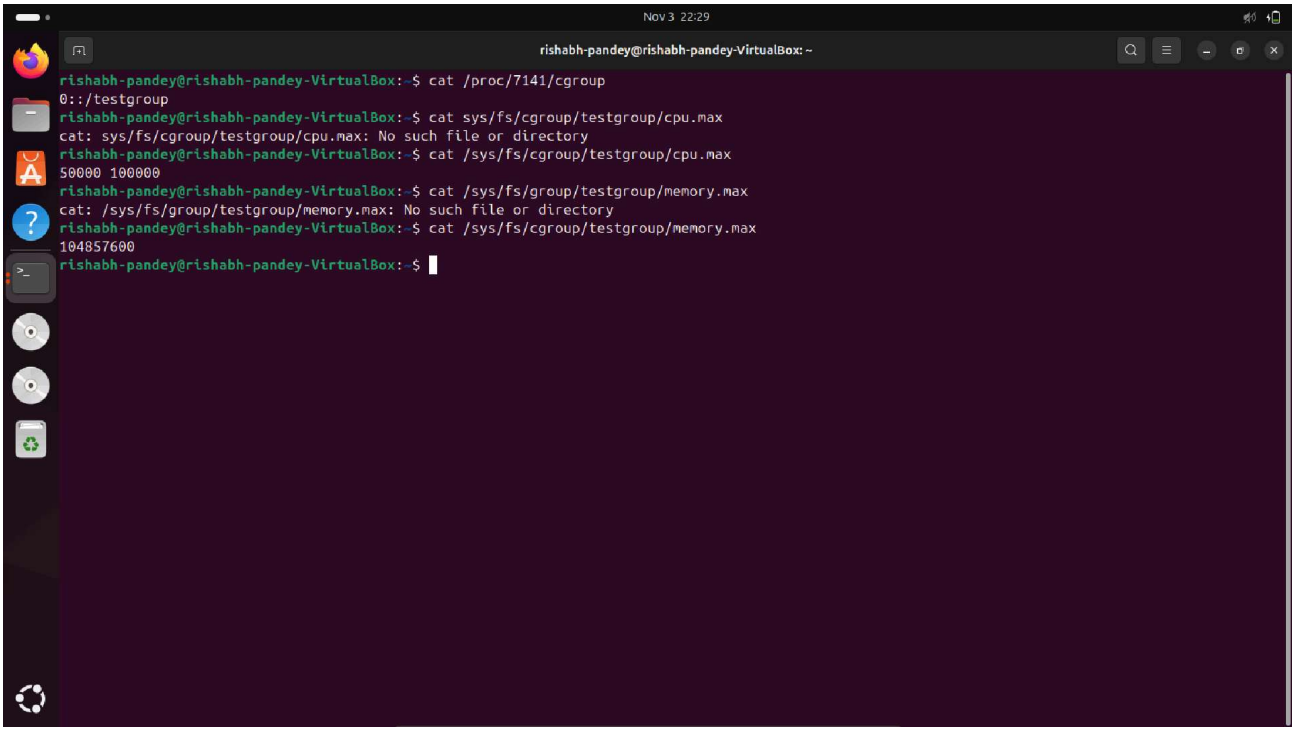
```
echo 50000 | sudo tee /sys/fs/cgroup/cpu/testgroup/cpu.cfs_quota_us
echo 100M  | sudo tee /sys/fs/cgroup/memory/testgroup/memory.limit_in_bytes
```

➕ Add PID 3050 to the Group

```
echo 3050 | sudo tee /sys/fs/cgroup/cpu/testgroup/cgroup.procs
```

👉 cgroups offer **fine-grained, kernel-enforced governance —** far beyond what `nice` can control.

📸 Output



🎯 12. Alternatives & Complements to `nice` / `renice`

1️⃣ Real-Time Scheduling — `chrt`

```
sudo chrt -f 50 sleep 1000
chrt -p <pid>
```

2️⃣ Disk I/O Prioritization — `ionice`

```
ionice -c 2 -n 7 tar -czf backup.tar.gz /home
```

3️⃣ CPU Affinity — `taskset`

```
taskset -c 1 firefox
```

4️⃣ cgroups for Granular Constraints

```
sudo cgcreate -g cpu,memory:/lowprio
echo 20000 | sudo tee /sys/fs/cgroup/cpu/lowprio/cpu.cfs_quota_us
echo 200M  | sudo tee /sys/fs/cgroup/memory/lowprio/memory.limit_in_bytes
echo 1234 | sudo tee /sys/fs/cgroup/cpu/lowprio/cgroup.procs
```

5 systemd-integrated Resource Control — `systemd-run`

```
systemd-run --scope -p CPUWeight=200 stress --cpu 4
```

6 Scheduling with `schedtool`

```
sudo schedtool -R -p 10 <pid>
```

✅ Consolidated Summary

Tool	Focus Area	Relation to `nice`
`chrt`	Real-time scheduling policies	Alternative (stronger)
`ionice`	Disk I/O prioritization	Complementary
`taskset`	CPU affinity	Complementary
`cgroups`	Kernel-level resource governance	Superset of capabilities
`systemd-run`	systemd + cgroup orchestration	Alternative + orchestration
`schedtool`	Custom scheduling classes	Alternative