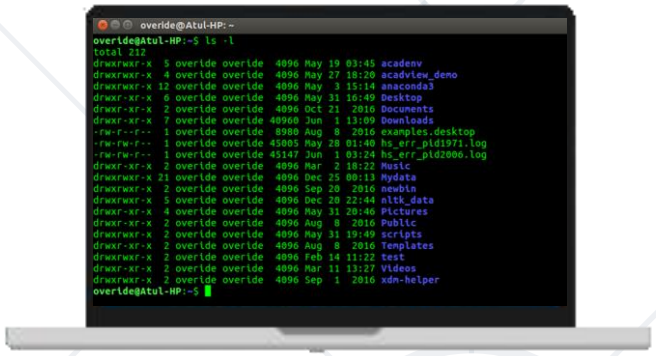
Linux and Linux Shell

Operation System, Linux OS, Linux Shell Commands, Environment Variables and SSH



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Operating System

Definition, Functions, Components, Examples

What is an Operating System?

- The **operating system** (OS) controls the computer (device)
  - Controls the hardware, processes (programs), resources, users
- Manages computer **hardware**, **software resources**, and provides **common services** for computer programs
  - It also coordinates all of this to make sure each program gets what it needs
- Allows users to **communicate with the computer** without knowing how to speak the computer's language

Important Functions of Operating Systems

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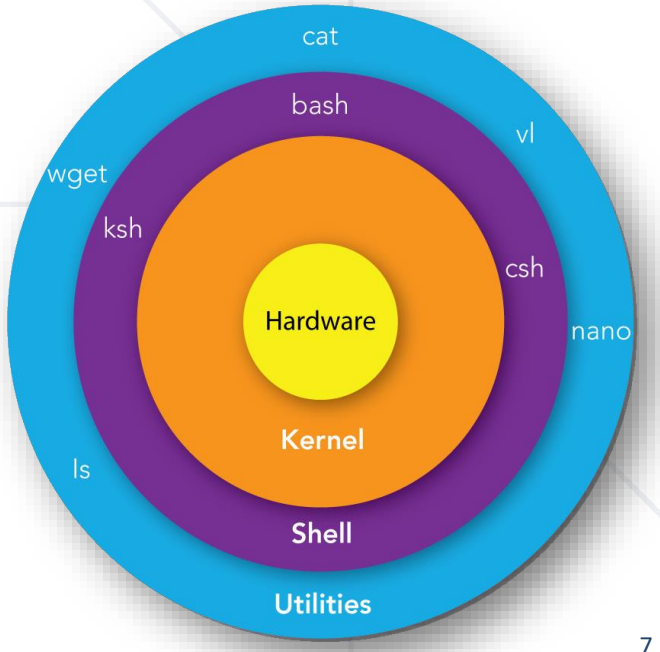
- **Process** management (programs, which run in the OS)
  - **Process scheduling** – OS decides which process gets the processor, when and for how much time
  - Keeps tracks of **processor** and status of a process
- **Memory** management
  - Keeps tracks of **primary memory** (RAM), allocates / de-allocates memory for each process
- **Users** / **privileges** management
- **Device** management, **file** management, **security**, etc.

Operating Systems Components

- **Kernel**
  - **Essential OS component** that loads first and remains within the main memory
  - Provides the basic level of control of all the **computer peripherals**
- **Shell**
  - An **interface** between the **OS** and the **user**
  - Helps users **access the services**, provided by the OS
  - It might be a **command-line interpreter** (**CLI**) or GUI app
- **Utilities** == small programs that provide additional capabilities to those, provided by the operating system
  - e.g., text editor, ZIP archiver, remote shell (SSH)



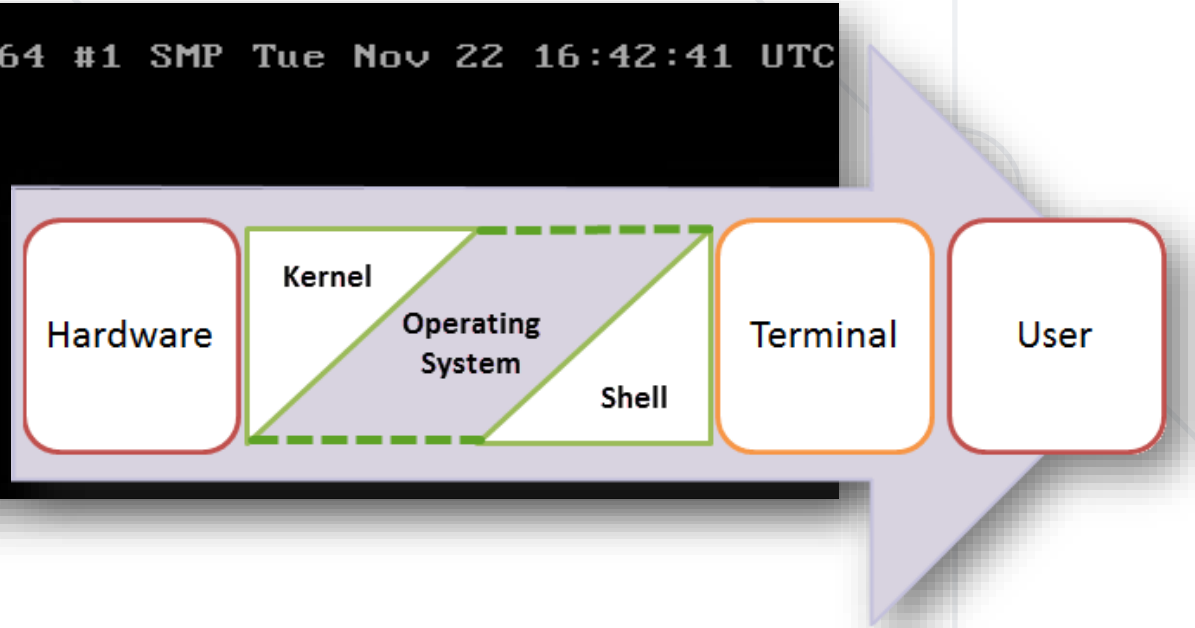
OS Security

- **OS security** refers to providing a **protection system** for computer system resources and most importantly **data**
- Computers must be protected against unauthorized access, malicious access to system memory, viruses, worms, etc.
- **OS security** may be approached in many ways
  - **Isolation** between processes (RAM, CPU, file system)
  - **Users**, **groups**, **permissions** (process, file system, others)
  - Filtering all incoming and outgoing **network traffic** through a **firewall**

Shell Definition

- Shell == **command line** interpreter
- It provides an interface that takes commands and passes them to the operating system
- When in GUI, we use **terminal emulators** to interact with the shell

```
[root@centosmin ~]# uname -a
Linux centosmin.softuni.lab 3.10.0-514.el7.x86_64 #1 SMP Tue Nov 22 16:42:41 UTC
 2016 x86_64 x86_64 x86_64 GNU/Linux
[root@centosmin ~]#
[root@centosmin ~]#
[root@centosmin ~]# cat /etc/hostname
centosmin.softuni.lab
[root@centosmin ~]#
[root@centosmin ~]# _
```



Linux Operating System

Architecture, Advantages and Disadvantages, Distribution

What is Linux?

- **Linux OS** is a very popular free, **open-source** operating system
  - https://github.com/torvalds/linux
  - Many **distributions** (variants), e.g., Ubuntu, Alpine, CentOS
- Linux is **NOT** the complete OS, it is just the **Linux Kernel**
  - Often the term is used to refer to the whole OS (Linux OS)
  - Linux Kernel is distributed along with all the necessary software and utilities, so that it can be used as an OS

Linux Distributions

- Linux has many **distributions** (vendors)
- **Differences** in console commands, file locations, package management systems
- Most popular Linux distributions
  - **Ubuntu** – user-friendly, stable, popular
  - **Alpine** – minimal, secure, lightweight
  - **CentOS** – enterprise-grade, stable, secure
  - **Debian** – robust, reliable, versatile
  - **Fedora** – community version of Red Hat Enterprise Linux

Linux Advantages

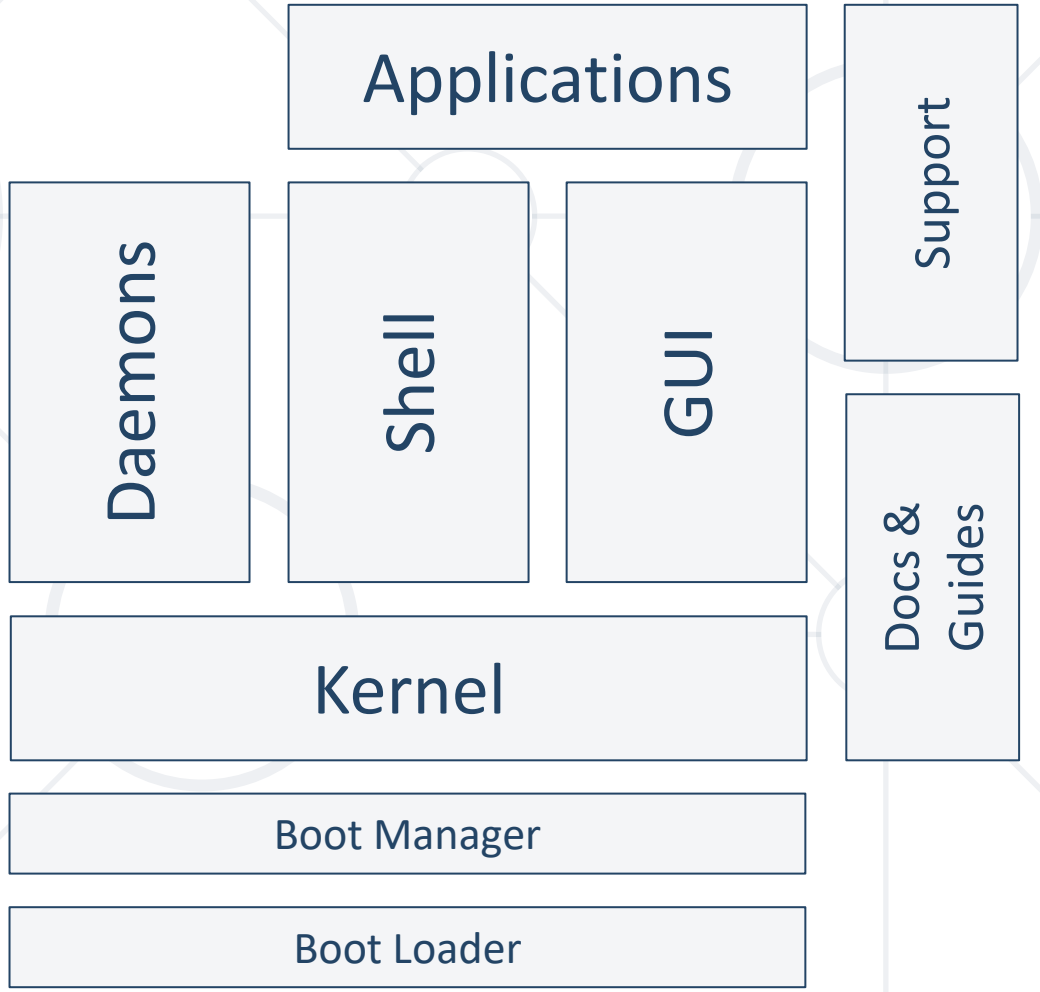
- Linux is **the most popular OS in the world**
  - You have many, many resources, available everywhere
  - Books, tutorials, videos, forums, questions / answers, certification programs, software, tools, etc.
- Linux is **open-source**, so anyone can contribute / enhance it
- Linux is **more secure** in comparison to other operating systems
- In Linux there is a larger number of **software updates**
- Linux provides **high performance** and efficiency

Linux Disadvantages

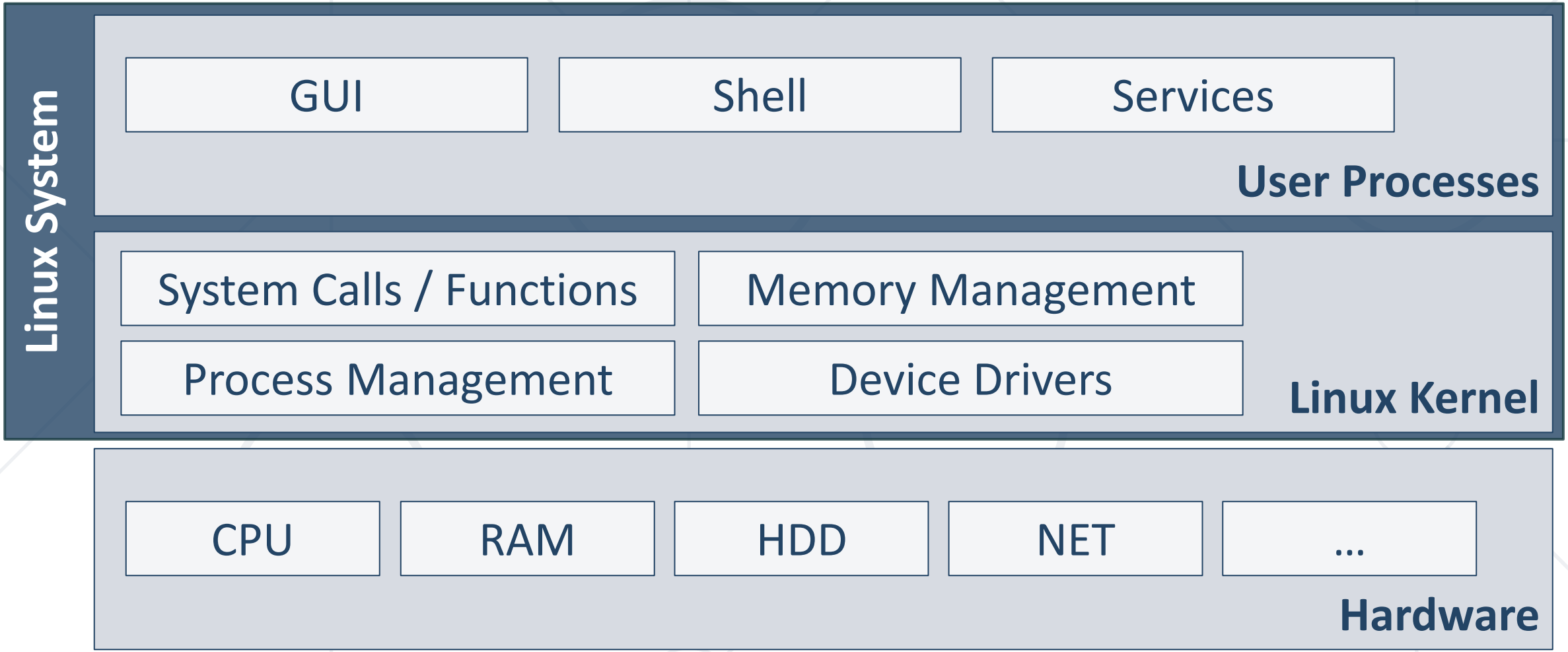
- Availability of apps: some **applications** that work on other OS **do not work in Linux**
- Other OS (like macOS, Windows) have better **usability** (UI and UX)
- **Learning curve**
  - It takes time and effort to master Linux
- **Lack** of standardization
  - Many distributions == many differences
- Some **hardware drivers** are not available for Linux

Linux OS Components

- **System** components
  - Boot loader
  - Boot manager
  - Kernel
- **User** components
  - Daemons (services)
  - Shell (command line)
  - Graphical environments
  - User applications
- Documentation and Support



Linux System Architecture

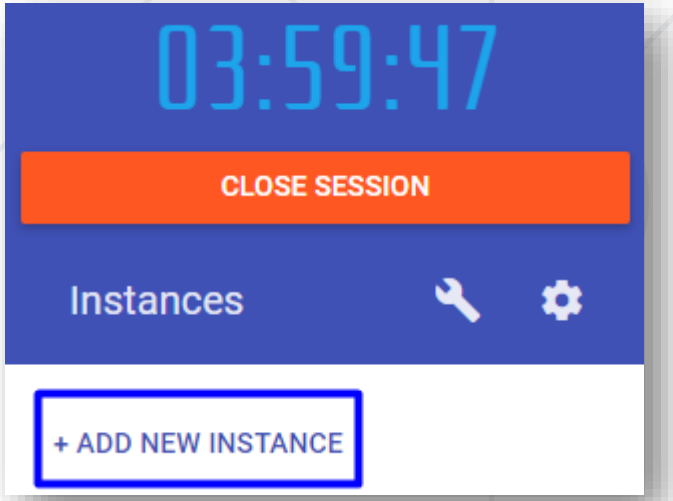


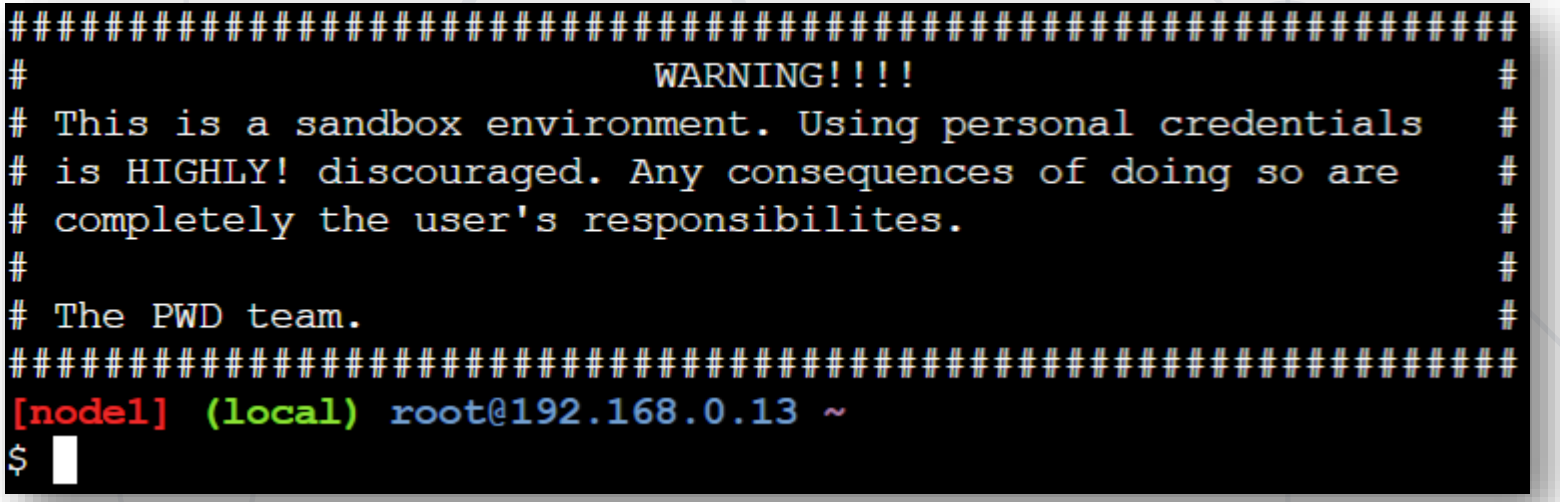
Linux Demo

Simple Commands on the Console

Docker Playground

- **Docker Playground** gives you an online **Linux virtual machine** to experiment with
  - Open Docker Playground and log in
  - Press **[Start]** and add a **new instance**
  - Now you have a Linux environment (Alpine Linux)





Display the Current User

- The **whoami** command displays the currently logged-in user
- Example

```
user@host:~$ whoami
```

```
[node1] (local) root@192.168.0.28 ~
$ whoami
root
```

Check Linux System Info

- Type the `uname -a` command to print OS information

```
[node1] (local) root@192.168.0.13 ~
$ uname -a
Linux node1 4.4.0-210-generic #242-Ubuntu SMP Fri Apr 16 09:57:56 UTC 2021
x86_64 Linux
```

1. Kernel name
2. Network hostname
3. Kernel release information
4. Kernel version information
5. Machine hardware name

Display Linux processes

- `top [options]`
- Examples

```
top - 11:10:12 up 54 min,  2 users,  load average: 0.00, 0.00, 0.00
Tasks: 105 total,   1 running, 103 sleeping,   1 stopped,   0 zombie
%Cpu(s):  0.0 us,  0.0 sy,  0.0 ni,100.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem :   1983.4 total,   1441.7 free,    167.8 used,    373.9 buff/cache
MiB Swap:   1965.0 total,   1965.0 free,      0.0 used.   1667.1 avail Mem

    PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
    179 root     -51   0       0      0      0 S   0.3   0.0   0:01.09 irq/18-v
   1531 root      20   0       0      0      0 I   0.3   0.0   0:00.43 kworker/
   1537 root      20   0       0      0      0 I   0.3   0.0   0:01.81 kworker/
```

```
# Display all active processes in interactive mode
user@host:~$ top

# Display user's processes with 2 sec delay 5 times
user@host:~$ top -d 2 -n 5
```

```
lsauser@ubuntu:~$ top
```

```
lsauser@ubuntu:~$ top -d 2 -n 5 -u lsauser
```

```
PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
977 lsauser   20   0   18488   9828   8256 S   0.0   0.5   0:00.05 systemd
979 lsauser   20   0  103304   3368      4 S   0.0   0.2   0:00.00 (sd-pam)
```

File System in Linux

Files, Directories and Basic Commands

The File System in Linux

- **File system** == OS component, which organizes and manages **files** and **directories** on a storage device (e.g., SSD disk)
  - Popular file systems: ext4, BTRFS, ZFS, NTFS
- Most Linux distributions use **ext4** file system
  - Storage is organized in **directories**, which hold **files** and **other directories**
  - **Files** hold data (e.g., text data / binaries)
  - **Special files**: symlinks, pipes, sockets, …

List files and directories

- Syntax

```
ls [options]
```

- Examples

```
user@host:~$ ls
```

```
user@host:~$ ls -al
```

File Types

- Files and directories
  - Regular (**-**)
  - Directory (**d**)
- Special files
  - Symbolic link (**l**)
  - Block (**b**)
  - Character (**c**)
  - FIFO pipe (**p**)
  - Local socket (**s**)

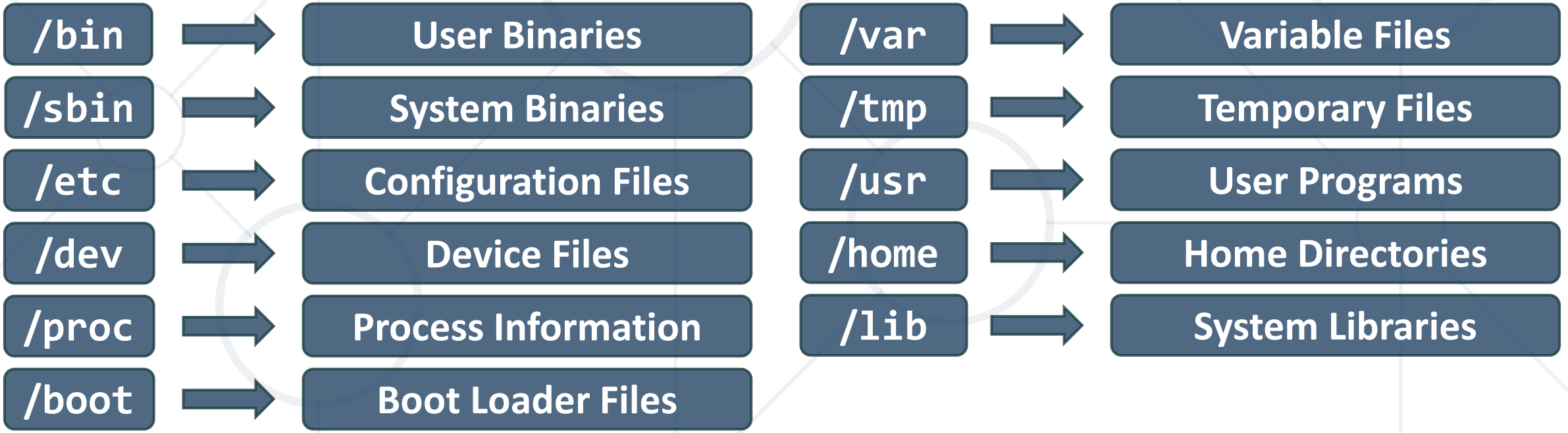
```
drwxr-xr-x  19 root root    4096 Mar 27 11:09 .
drwxr-xr-x  19 root root    4096 Mar 27 11:09 ..
lrwxrwxrwx   1 root root       7 Apr 23  2020 bin -> usr/bin
drwxr-xr-x   2 root root    4096 Apr 23  2020 boot
drwxr-xr-x   9 root root    3000 Mar 27 11:09 dev
drwxr-xr-x  94 root root    4096 Mar 27 12:10 etc
drwxr-xr-x   3 root root    4096 Dec 11  2021 home
-rwxr-xr-x   3 root root 1440152 May  7  2022 init
lrwxrwxrwx   1 root root       7 Apr 23  2020 lib -> usr/lib
```

```
crw-------  1 root root   1,   1 Mar 27 11:09 mem
drwxr-xr-x  2 root root        60 Mar 27 11:09 net
crw-rw-rw-  1 root root   1,   3 Mar 27 11:09 null
crw-------  1 root root  10, 144 Mar 27 11:09 nvram
crw-------  1 root root 108,   0 Mar 27 11:09 ppp
crw-rw-rw-  1 root root   5,   2 Mar 27 12:33 ptmx
drwxr-xr-x  2 root root        0 Mar 27 11:09 pts
brw-------  1 root root   1,   0 Mar 27 11:09 ram0
brw-------  1 root root   1,   1 Mar 27 11:09 ram1
```

Examine Root Directory files

- Syntax

```
ls /
```



Absolute vs Relative Path

- **Absolute path** (starts with **/**)
  - Calculated from the **root** of the **file system tree**, e.g., `/dev/random`
- **Relative path** (no leading /, uses **.** and **..**)
  - Calculated from the **current working directory**, e.g., `../../bin/`
- If we are in **/home/user** and we want to list folders

```
# Absolute notation
user@host:~$ ls -al /usr/bin

# Relative notation
user@host:~$ ls -al ../
```

Files and Directories

- Create directories

```
mkdir [options] directory [directory …]
```

- Copy files and directories

```
cp [options] source dest
```

- Move/Rename files

```
mv [options] source dest
```

- Remove files or directories

```
rm [options] file [file …]
```

Files and Directories

- Print the current working directory

```
pwd
```

- Output the first part (10 lines by default) of files

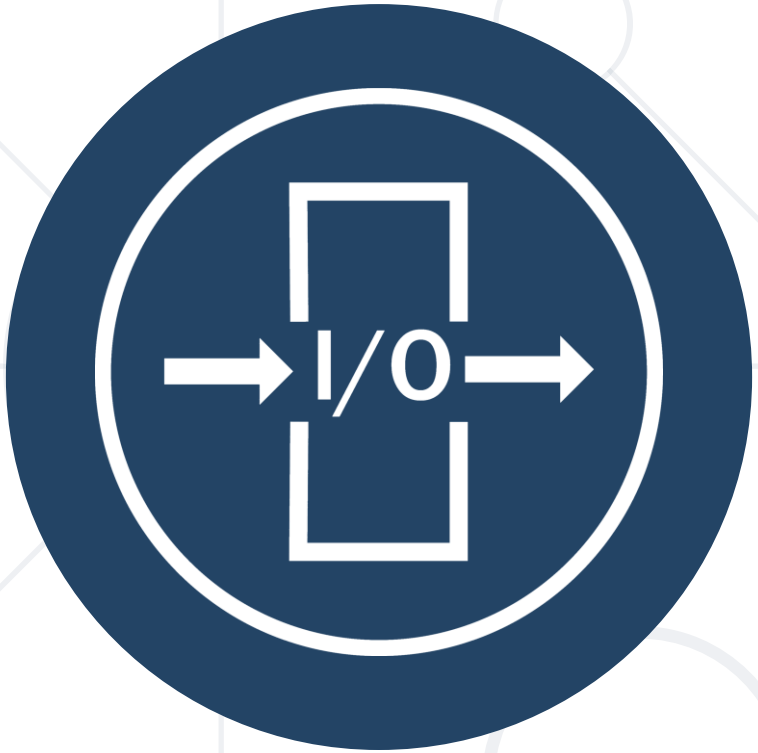
```
head [options] [files]
```

- Output the first part (10 lines by default) of files

```
tail [options] [files]
```

- Read data from the file and return the content as output

```
cat [filename]
```

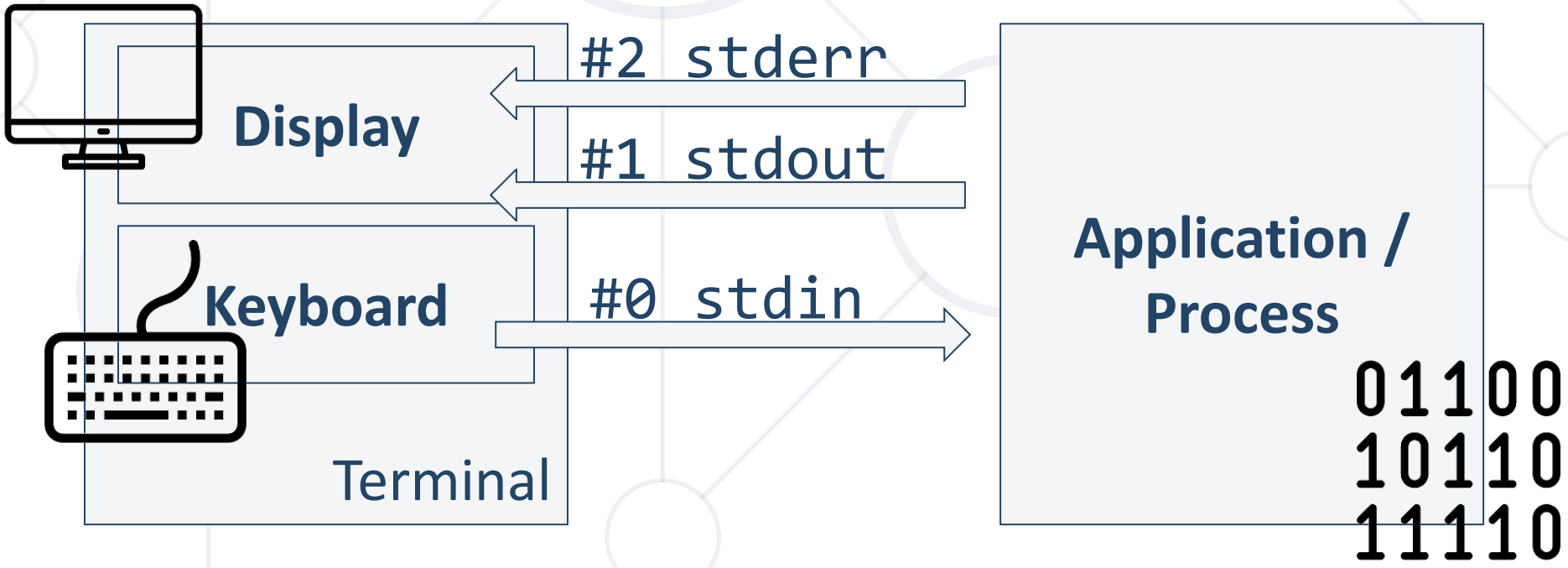


Input / Output Streams

Standard File Descriptors. Redirection

Standard File Descriptors

- `stdin` == standard **input** stream (N.0)
- `stdout` == standard **output** stream (N.1)
- `stderr` == standard **error output** stream (N.2)



Redirect Output (>)

- Redirect output streams (**stdout** or **stderr**) with **target overwrite**
- Examples

```
user@host:~$ echo 'Hello World!' > hello.txt

user@host:~$ echo 'Hello World!' 1> hello.txt
```

The same

1 == stdout

```
lsauser@ubuntu:~$ echo 'Hello World!' > hello.txt
lsauser@ubuntu:~$ echo 'Hello World!' 1> hello.txt
```

```
lsauser@ubuntu:~$ cat hello.txt
Hello World!
```

Redirect Output with Append (>>)

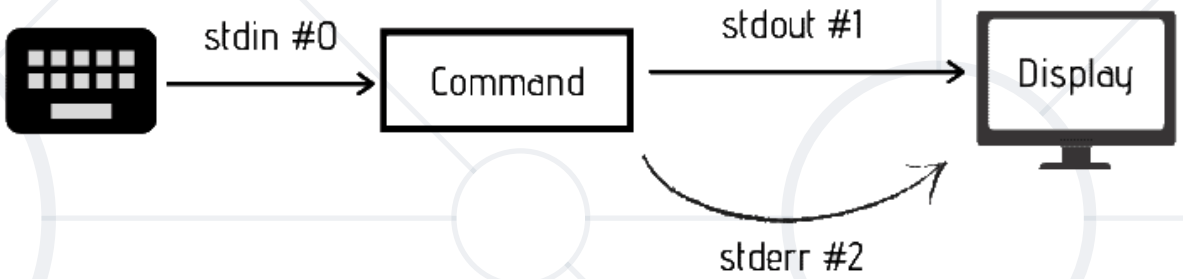
- Redirect output streams (**stdout** or **stderr**) with **target append**
- Example

```
user@host:~$ echo 'Line #2' >> file.txt
```

```
lsauser@ubuntu:~$ cat file.txt
Line #1
lsauser@ubuntu:~$ echo 'Line #2' >> file.txt
lsauser@ubuntu:~$ cat file.txt
Line #1
Line #2
```

Redirect Input (<)

- Redirect input stream (**stdin**)
  - Usually, it is omitted
- Examples




```
user@host:~$ cat < hello.txt

user@host:~$ cat hello.txt
```

```
lsauser@ubuntu:~$ cat < hello.txt
Hello!
```

```
lsauser@ubuntu:~$ cat hello.txt
Hello!
```

The same

Command Sequences

Execute Multiple Commands. Substitution

Commands Sequences

- Execute in order (disconnected)
  - **Sequence**: command1 **;** command2
- Execute in order (connected)
  - **Pipe**: command1 **|** command2
- Execute conditionally
  - On **Success**: command1 **&&** command2
  - On **Failure**: command1 **| |** command2

Sequence (;)

- Always execute **next command**
- Example

```
user@host:~$ ls non-existing-file.txt ; echo Ok
```

```
lsauser@ubuntu:~$ ls non-existing-file.txt ; echo Ok
ls: cannot access 'non-existing-file.txt': No such file or directory
Ok
```

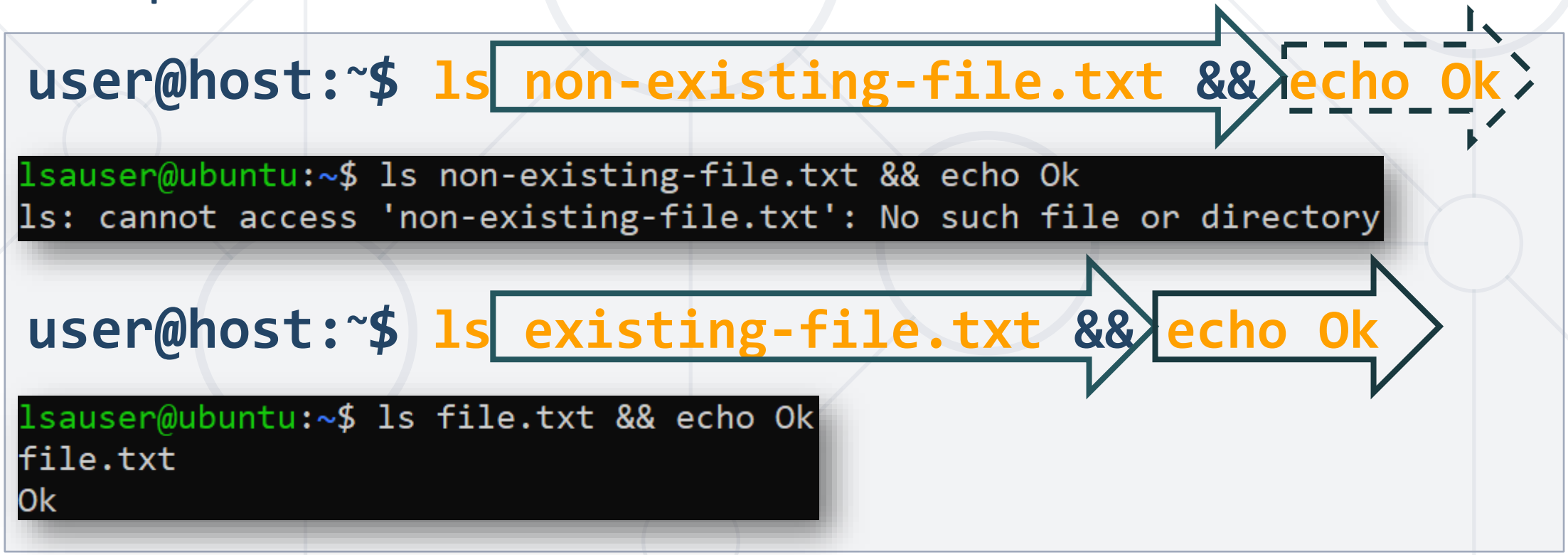
Pipe (|)

- **Chaining** two or more programs' **output together**
- Example


```
lsauser@ubuntu:~$ ls | sort | head -n 3
copy-file.txt
dir1
dir2
```

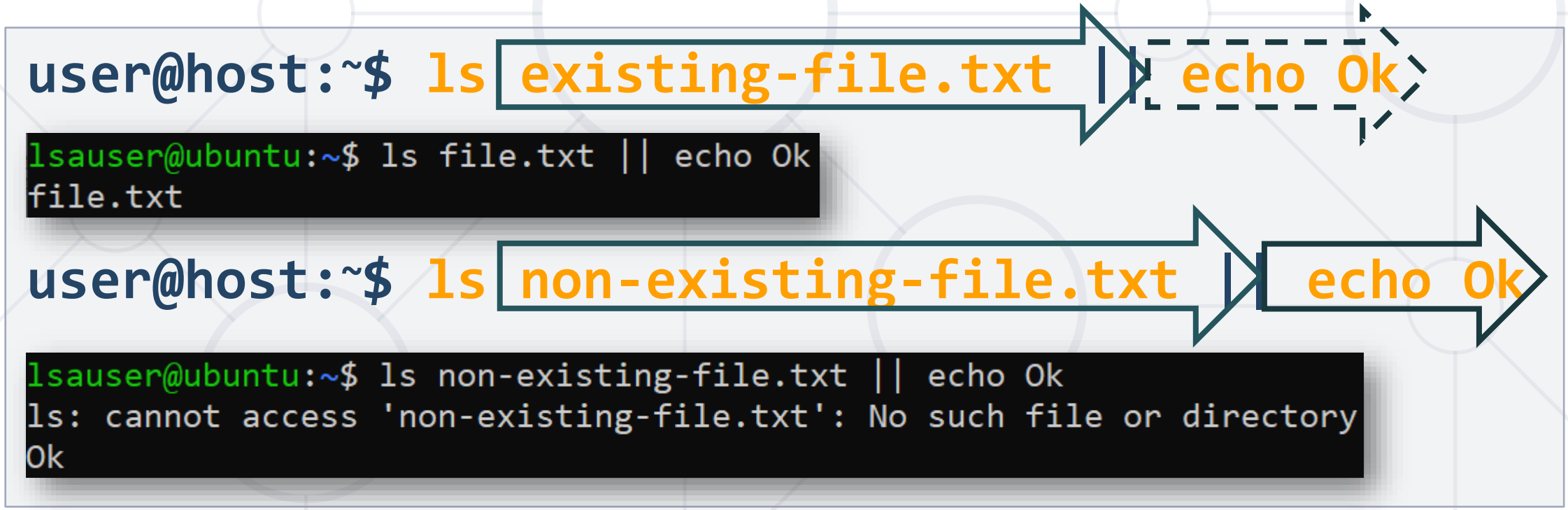
On Success (&&)

- **Next command is executed** if previous one exited with a **status of 0** (success)
- Examples



On Failure (||)

- **Next command is NOT attempted** if previous one exited with **0**
- Examples



Users and Groups

Manage Users and Groups

Users in Linux

- Users file (`/etc/passwd`)

```
root:x:0:0:root:/root:/bin/bash
...
madmin:x:1000:1000:M.Admin:/home/madmin:/bin/bash
... 1 2 3 4 5 6 7
```

1. Username (login)
2. Password placeholder
3. User ID
4. Group ID
5. Comment (full name, phone, etc.)
6. Home directory
7. User shell

Groups in Linux

- Groups file (`/etc/group`)

```
root:x:0:
...
wheel:x:10:madmin (4)
...
madmin:x:1000:
...(1) (2) (3)
```

1. Group name
2. Password placeholder
3. Group ID
4. Group members

Access Rights

Users, Groups and Permissions in the File System

Access Rights in the Linux File System

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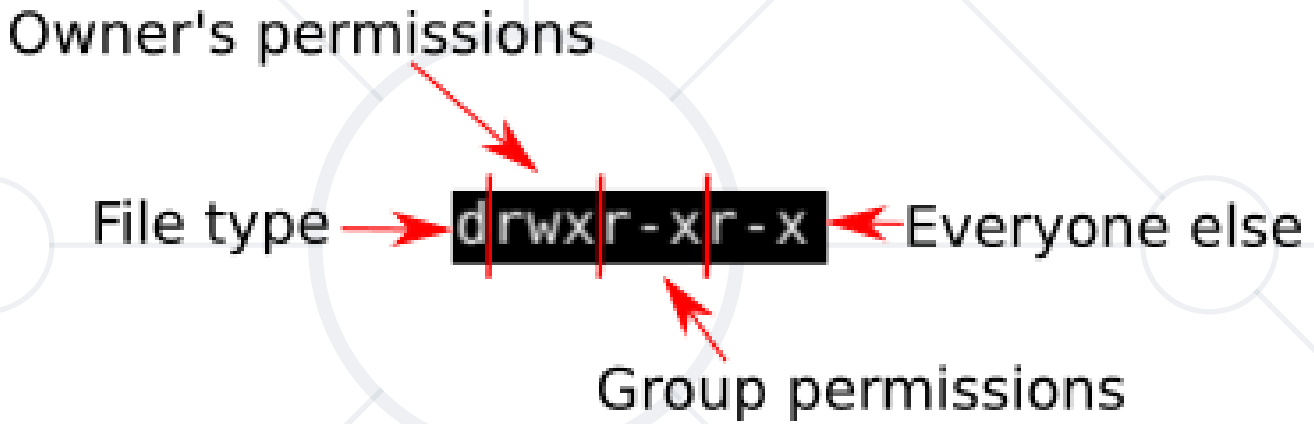
```
[root@vmi937769 softunisites]# ls -al
total 112
drwx--x--x 26 softunisites softunisites 4096 Feb 13 23:17 .
drwx--x--x 17 root         root         4096 Jan 23 14:36 ..
lrwxrwxrwx  1 softunisites softunisites   38 Jan  7 23:28 access-logs -> /etc/apache2/
drwxr-x---  7 softunisites nobody       4096 Mar 25 03:33 conf.softuni.bg
drwxr-xr-x  3 softunisites softunisites 4096 Feb 13 23:17 .cpaddons
drwx------  6 softunisites softunisites 4096 Mar 27 01:03 .cpanel
drwxr-x---  6 softunisites nobody       4096 Mar 25 03:33 fest.softuni.bg
```

- **Group**
- **Owner**
- **Access Rights**
  read / write / execute

File Permissions and Octal Masks



Permissions	Octal Mask	Description
`---------`	000	No permissions
`rw-rw-rw-`	666	Everyone read + write
`rwxr-xr-x`	755	Owner full access, others read + execute
`rwxrwxrwx`	777	Everyone read, write, and execute

Access Rights

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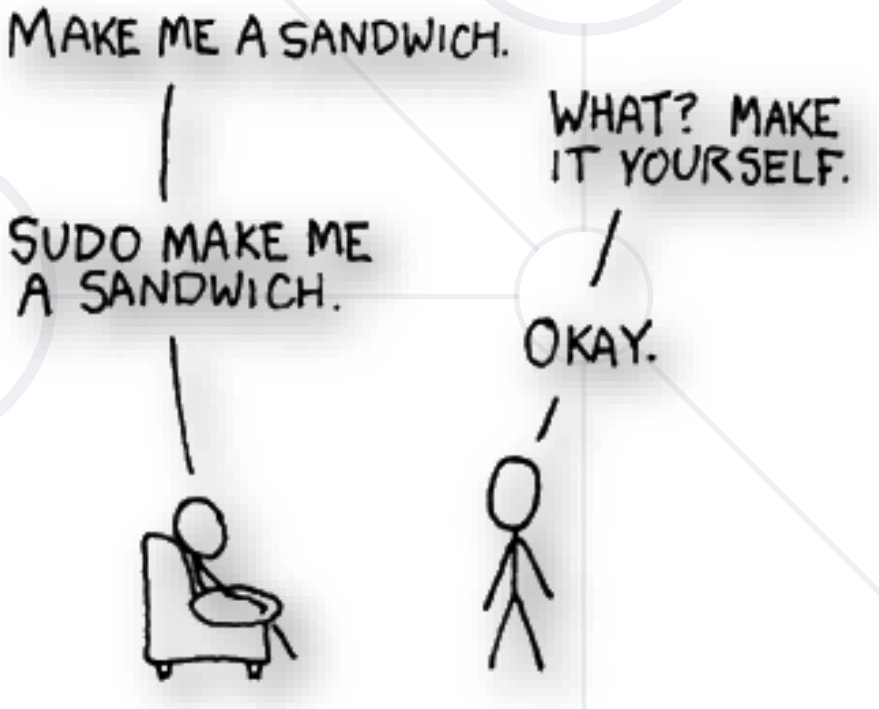
	Read	Write	Execute
Files	Allow a user to view the contents of a file	Allow a user to modify and delete the file	Allow a user to execute a file (the user must also have read permission)
Directories	Allow a user to view the names of files in a directory	Allow a user to delete the directory, modify its contents and modify the contents of files that the user can read	Allow a user to access, or traverse into, a directory and access metadata about files in it

SUDO (SuperUser DO) Configuration

- **sudo** is used to access restricted files and operations
  - Controls **who** can do **what** and from **where**
- Temporarily allows **ordinary users** to **perform administrative tasks**
  - Without logging in as the root user

```
sudo [command]
```



sudo

- Execute a command as **another user**

```
# Execute commands as another user
user@host:~$ sudo -u testuser whoami

# Switch to a user
user@host:~$ sudo su testuser

# Switch to a user with a login shell
user@host:~$ su - testuser

# Execute a single command as root
user@host:~$ sudo chmod +x hello.txt
```

Commands

- Change the permissions of a file or directory for all types of users
  - Operations modify the user or file level permissions

```
chmode [operations] [file/directory name]
```

- Change file owner and group

```
chown [options] [owner][:[group]] file
```

- Change group ownership

Can be replaced with "."

```
chgrp [options] group file
```

Live Demo

Getting to Know the Console

Environment Variables

Linux Environment Variables

- **Environment variables** == **dynamic** variables used by the Linux shell
  - Provide config settings to Linux apps
  - They follow the **<NAME>=<VALUE>** formatting
  - They are case-sensitive
  - By convention environment variable names use **CAPITAL_LETTERS**

```
$ env
DOCKER_VERSION=20.10.17
CHARSET=UTF-8
HOSTNAME=node2
DOCKER_TLSENABLE=false
COMPOSE_VERSION=2.6.1
DOCKER_BUILDX_VERSION=0.8.2
PWD=/root
```

Commands

- List all environment variables

```
env
printenv
```

- Print a single environment variable

```
printenv HOME
echo $HOME
```

- Sets a new environment variable

```
export VAR=VALUE
```

Live Demo

Getting to Know Environment Variables

Secure Shell (SSH)

Connecting to Remote Linux Machine

SSH (Secure Shell)

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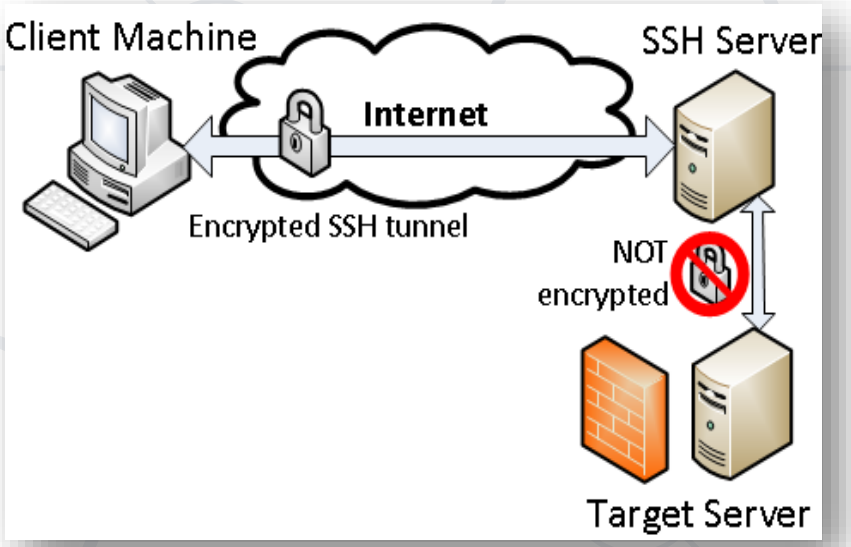
- **Secure Shell (ssh)** allows connecting to a remote machine's console

```
ssh 192.168.0.28 -l root
```

```
$ ssh 192.168.0.28 -l root
##############################################################
#                          WARNING!!!!                       #
# This is a sandbox environment. Using personal credentials  #
# is HIGHLY! discouraged. Any consequences of doing so are   #
# completely the user's responsibilites.                     #
#                                                            #
# The PWD team.                                              #
##############################################################
[node1] (local) root@192.168.0.28 ~
$ exit
logout
Connection to 192.168.0.28 closed.
[node2] (local) root@192.168.0.27 ~
$
```

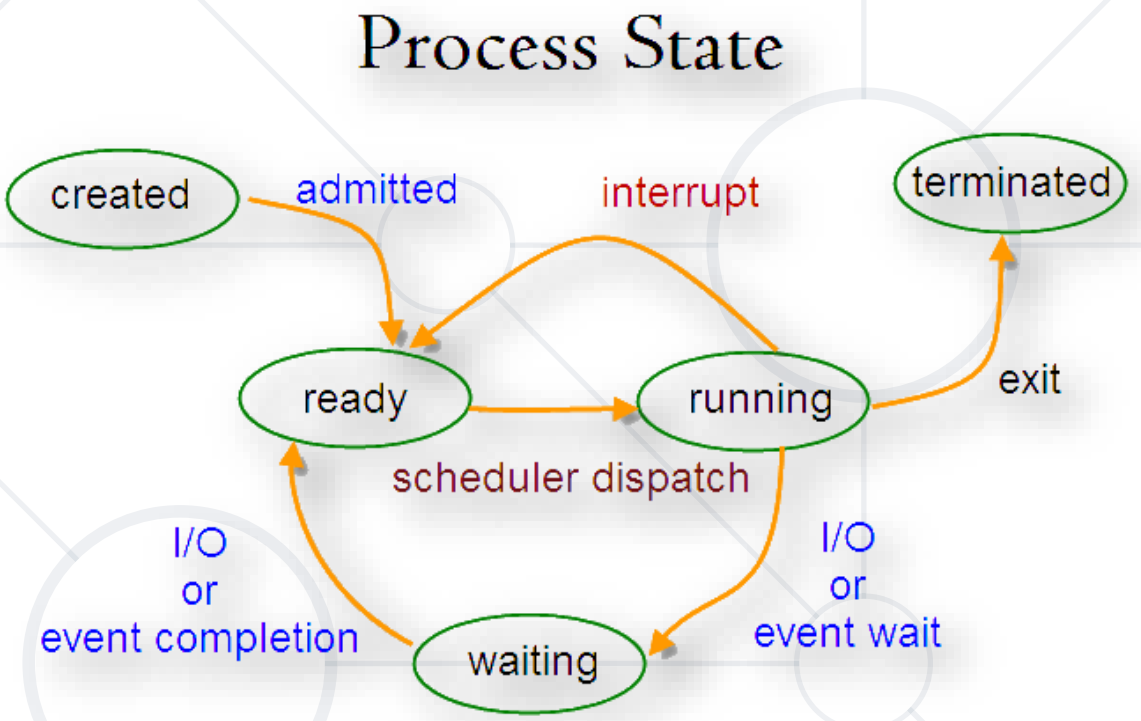


Processes

Monitoring and Management

Processes and Jobs

- **Process**
  - **Running a program** with its own address space
- **Job**
  - **Interactive program** that doesn't detach
  - It can be suspended with **[Ctrl]+[Z]**
  - It can execute in the foreground or background mode



Commands

- Display status of jobs

```
jobs [options] [jobspec]
```

- Report a snapshot of the current processes

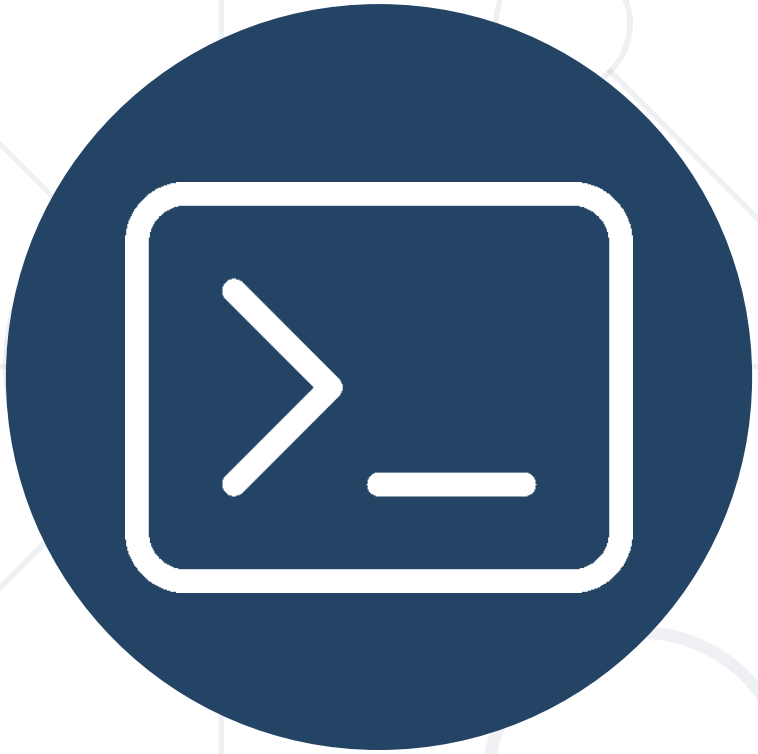
```
ps [options]
```

- Send a signal to a job or process

```
kill [options] pid | jobspec
```

- Kill processes by name

```
killall [options] process
```



More Linux Commands

apt

- `apt` provides a high-level command line interface for the package management system

```
apt install <package>
```

- Download package information from all configured sources

```
apt update
```

- Install available upgrades of all packages, currently installed on the system, from the configured sources

```
apt upgrade
```

Data Fetching

- `wget` == free utility for non-interactive download of files from the Web

```
wget [options] URL
```

- `curl` == tool for transferring data from or to a server

```
curl [options] URL
```

Live Demo

Getting Help

Summary

- **Operating systems** manage all of the software and hardware on the computer
- **Linux OS** distributions & file system
- **Shell** definition
- **Command sequences**
- **Environmental variables** – dynamic named variables
- Linux **commands** – used to interact with the system

Questions?

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