Procesamiento Masivo de datos

Alex Di Genova

12/08/2022

Outline

- Big Data
- Sistemas distribuidos
    - Tipos y arquitecturas.
- Linux

Big Data

Visión global

Byte	B	10^0	1
Kilobyte	KB	10^3	1,000
Megabyte	MB	10^6	1,000,000
Gigabyte	GB	10^9	1,000,000,000
Terabyte	TB	10^{12}	1,000,000,000,000
Petabyte	PB	10^{15}	1,000,000,000,000,000
Exabyte	EB	10^{18}	1,000,000,000,000,000,000

- Astronomía
- Genómica
- Redes Sociales
- Youtube

Stephens, Zachary D., et al. "**Big data: astronomical or genomical?**." *PLoS biology* 13.7 (2015): e1002195.

Visión global

Data Phase	Astronomy	Twitter	YouTube	Genomics
Acquisition	25 zetta-bytes/year	0.5–15 billion tweets/year	500–900 million hours/year	1 zetta-bases/year
Storage	1 EB/year	1–17 PB/year	1–2 EB/year	2–40 EB/year
Analysis	In situ data reduction	Topic and sentiment mining	Limited requirements	Heterogeneous data and analysis
	Real-time processing	Metadata analysis		Variant calling, ~2 trillion central processing unit (CPU) hours
	Massive volumes			All-pairs genome alignments, ~10,000 trillion CPU hours
Distribution	Dedicated lines from antennae to server (600 TB/s)	Small units of distribution	Major component of modern user's bandwidth (10 MB/s)	Many small (10 MB/s) and fewer massive (10 TB/s) data movement

doi:10.1371/journal.pbio.1002195.t001

- Astronomia
- Genomica
- Redes Sociales
- Youtube

Stephens, Zachary D., et al. "**Big data: astronomical or genomical?**." *PLoS biology* 13.7 (2015): e1002195.

Visión global

Octubre 2020,
Sebastian
Steudtner
(German)
26 metros

- Astronomía
- Genómica
- Redes Sociales
- Youtube

- Infraestructura (computadores, redes)
- algoritmos (software)

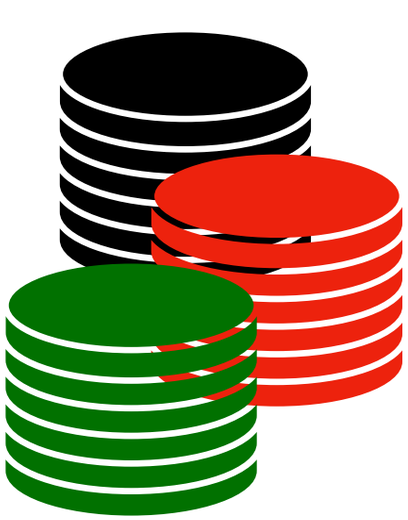
Qué es exactamente el “big data”?

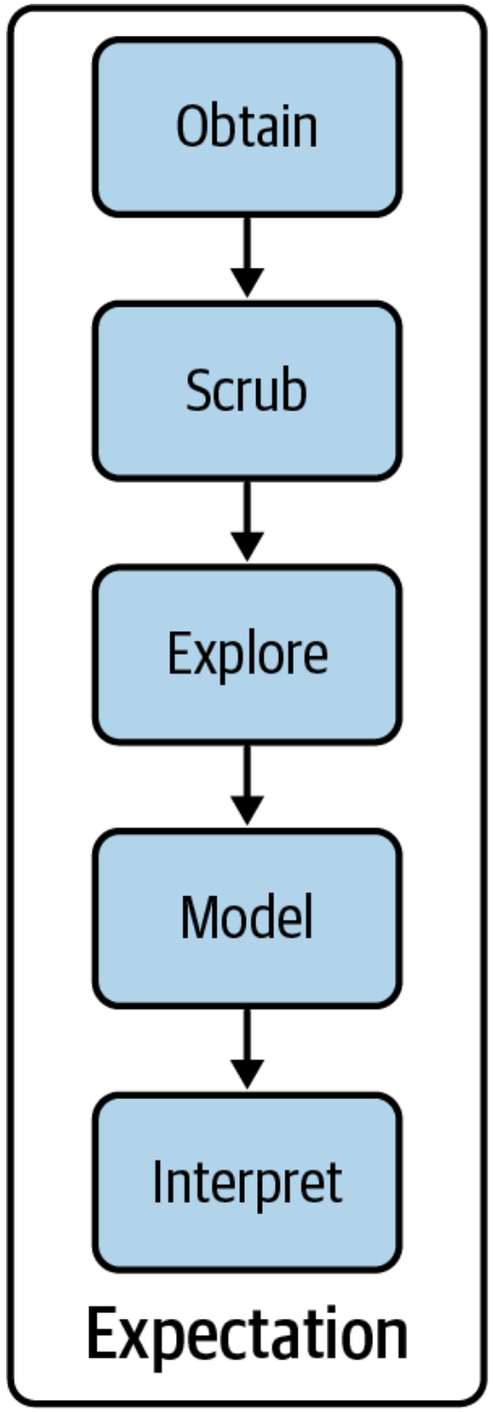
- No es solamente la cantidad.
  - Velocidad (generación)
  - Variedad (tipos)
  - Información (extraer)
  - Datos:
    - Estructurados (SQL)
    - Semi-estructurados (archivos)
    - No estructurados (imagénes, texto, sonidos, video, etc)

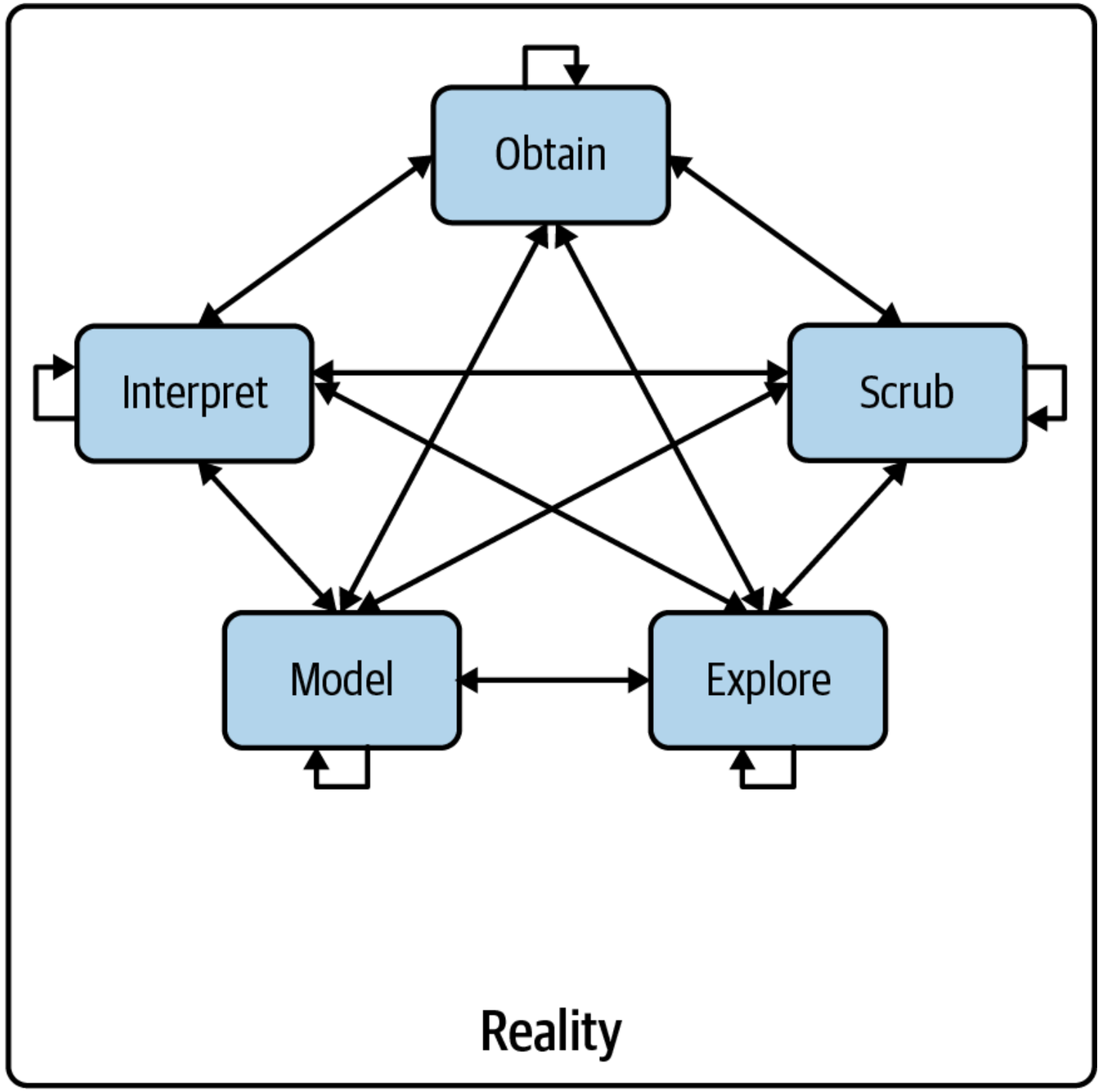
- Las 3Vs:
  - Volumen: Son datos demasiado grandes para ser procesados y analizados utilizando métodos tradicionales.
  - Velocidad: Generación y transmisión (tiempo real).
  - Variedad: diversos formatos.
  - Desafios:
    - **Almacenamiento y Procesamiento**
    - **Calidad de los Datos: coherencia de los datos.**
    - **Privacidad y Seguridad**

Data science

Expectation vs Reality







DATA -> INFORMATION

Sistemas Distribuidos

Sistemas distribuidos

Gran cantidad de computadores conectados por una red de alta velocidad.

- Un sistema distribuido es una **colección de computadoras** independientes que aparece ante sus usuarios como un **solo sistema coherente.**

Sistemas distribuidos

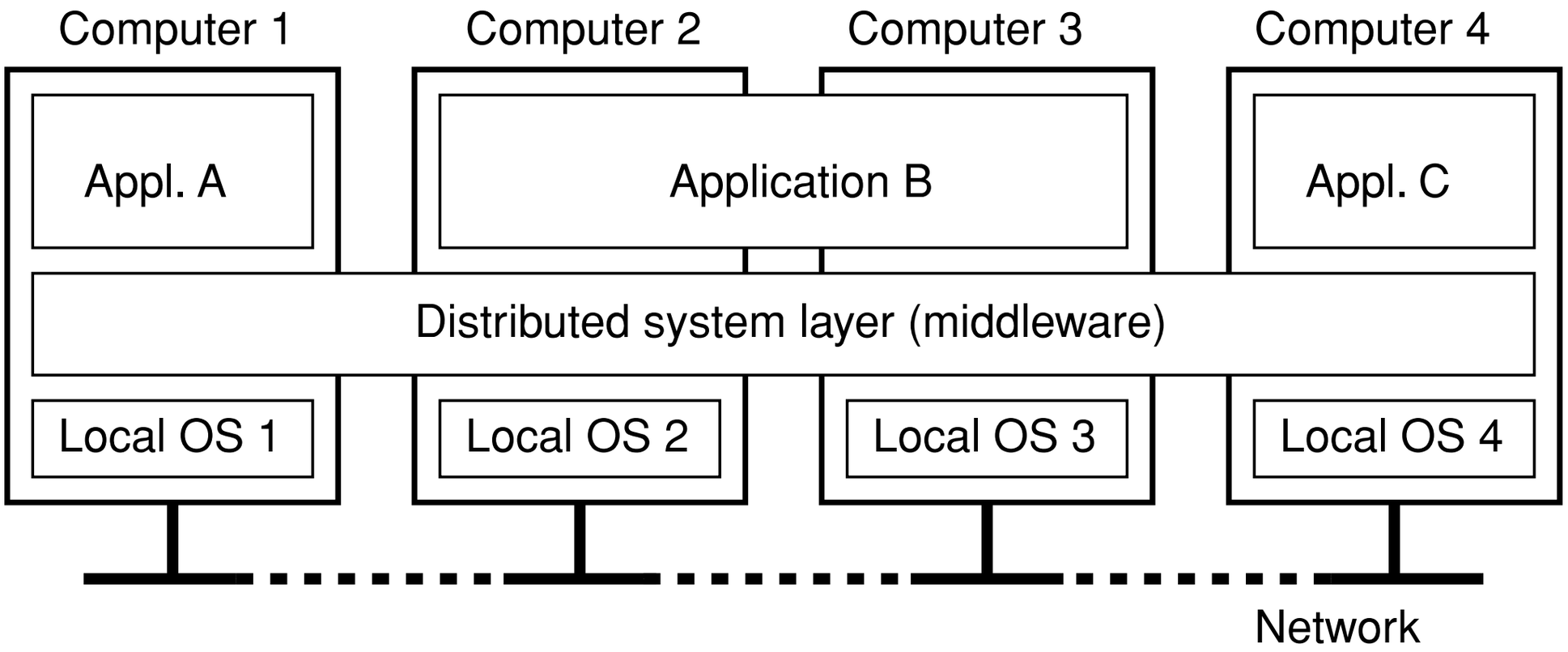
Red

- Un sistema distribuido es una **colección de computadoras** independientes que aparece ante sus usuarios como un **solo sistema coherente.**
  - L**as computadoras necesitan colaborar.**
  - **Cómo establecer esta colaboración** se encuentra en el corazón del desarrollo de sistemas distribuidos.
- Dentro de un sistema distribuido, podrían existir computadoras de alto rendimiento hasta pequeños nodos (**heterogéneo**).
- No se hacen suposiciones sobre **la forma en que se interconectan las computadoras.**

Sistemas distribuidos

- Un sistema distribuido es una **colección de computadoras** independientes que aparece ante sus usuarios como un **solo sistema coherente.**
- **Características**
  - Las diferencias entre las distintas computadoras y las formas en que se comunican están en su mayoría **ocultas** a los usuarios.
  - Los usuarios y las aplicaciones pueden **interactuar** con un sistema distribuido de manera consistente y uniforme
  - Relativamente fácil de **expandir o escalar**.
  - **Alta disponibilidad.**

Sistemas distribuidos



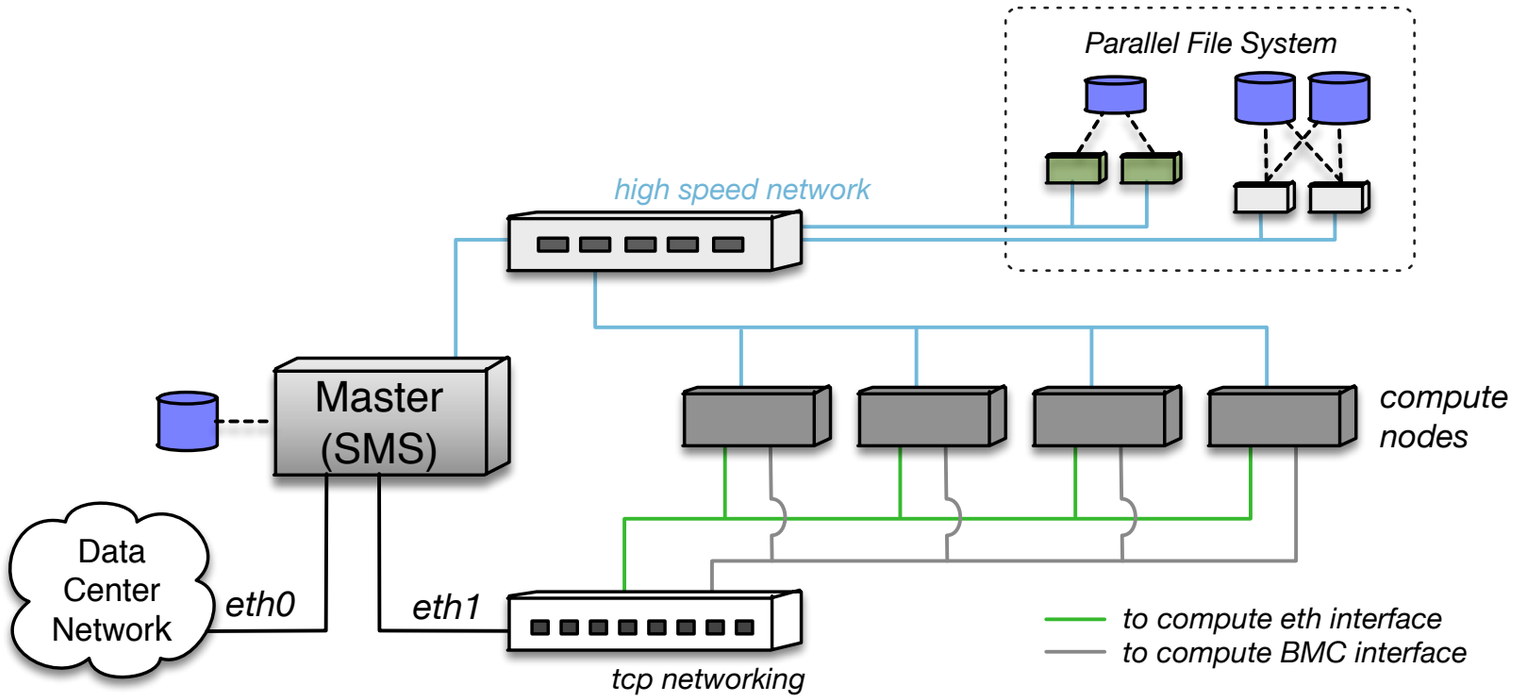
- El middleware (sotfware) se extiende sobre varias máquinas y ofrece a cada aplicación/usuario la misma interfaz para interaccionar con el SD.

- Un sistema distribuido debe hacer que los recursos sean fácilmente accesibles (1); debería ocultar razonablemente el hecho de que los recursos se distribuyen a través de una red(2); debe ser abierto — Interface definition languaje (3); y debe ser escalable(4).

Sistemas distribuidos

Tipos

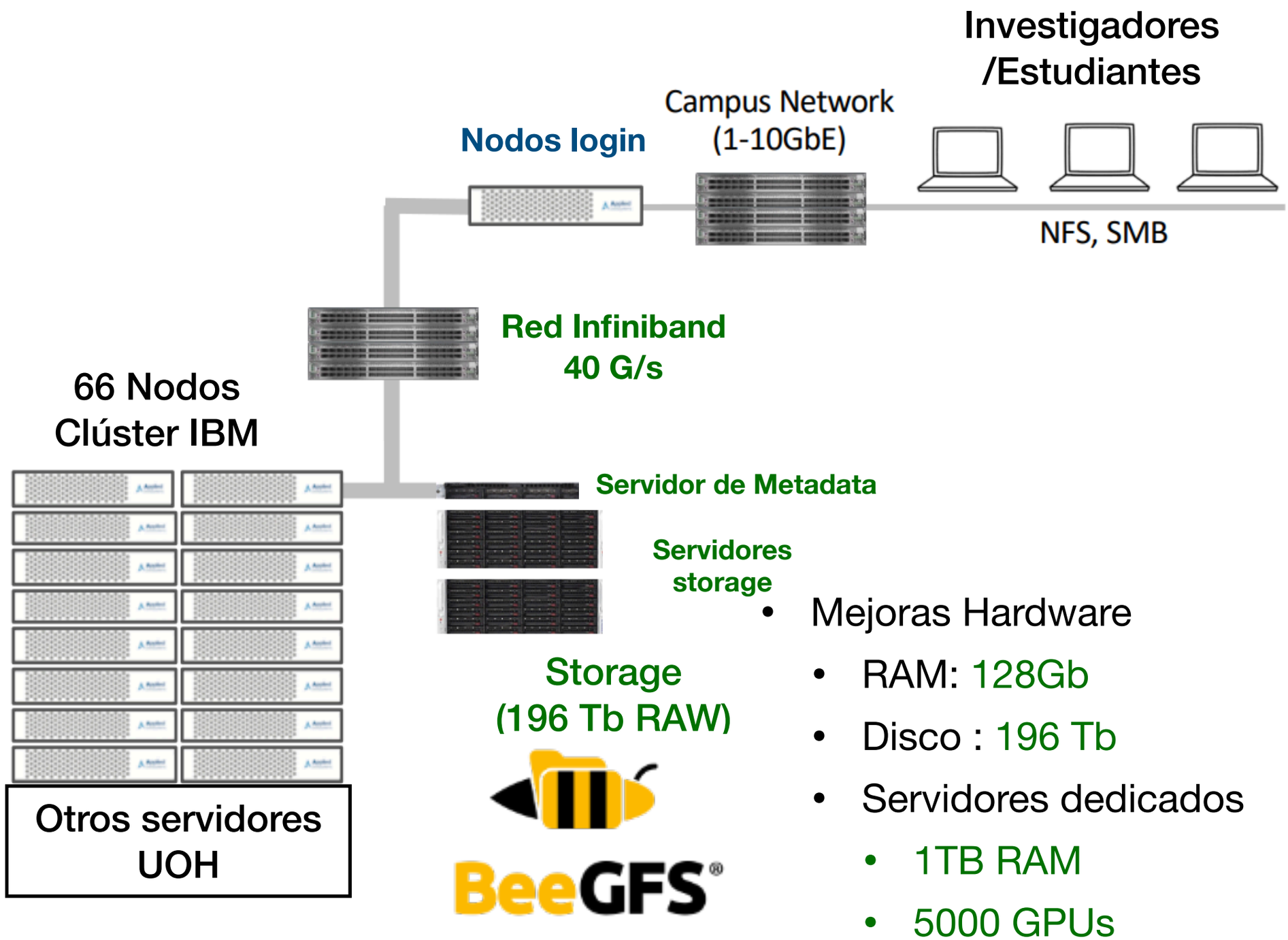
- Sistemas de cómputo distribuido
  - Clúster de cómputo
    - Hardware similar
    - Red local de alta velocidad
    - Mismo sistema operativo



The **master** handles the allocation of nodes to a particular parallel program, maintains a batch queue of submitted jobs, and provides an interface for the users of the system.

Arquitectura HPC-UOH

Sala Ex DTI
(Costado sala
A023 informática)



- Mejoras Hardware
  - RAM: 128Gb
  - Disco : 196 Tb
  - Servidores dedicados
    - 1TB RAM
    - 5000 GPUs

Kütral
software

CentOS 7

BeeGFS®

ANSIBLE

slurm
workload manager

Spack

APPTAINER

RStudio®

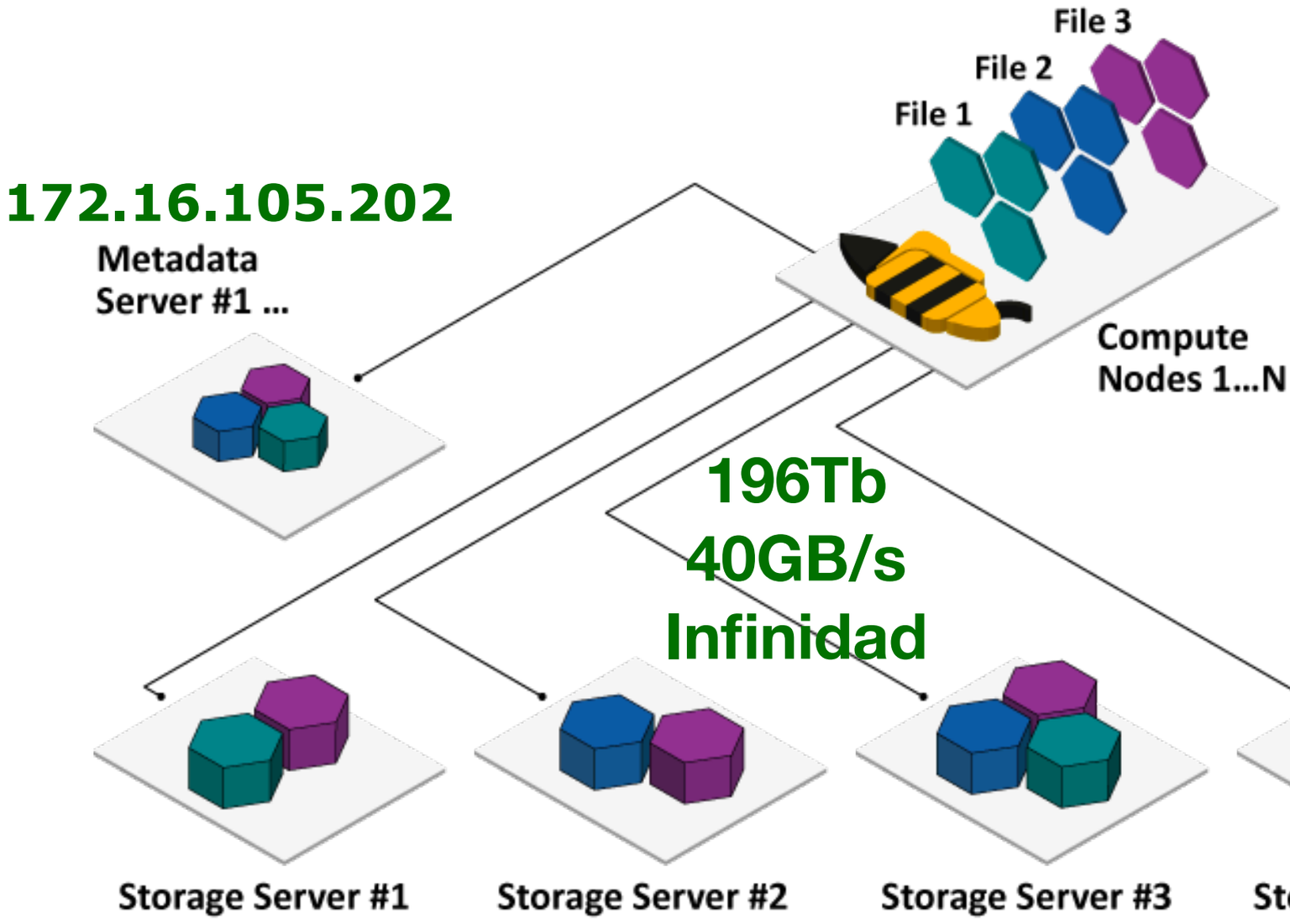
nextflow

OPEN OnDemand

100% open source

Kütral software

BeeGFS



- ~39 millones de canciones en formato MP3
- ~2 millones de peliculas en calidad estándar

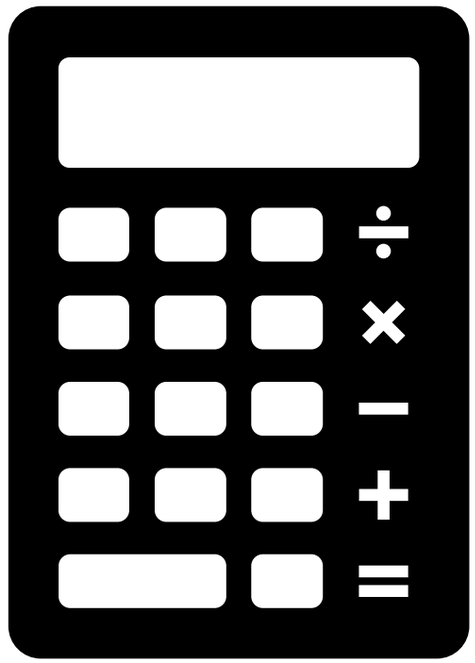
BeeGFS permite acceder a los archivos de manera rápida y eficiente desde cualquier nodo del clúster.

```
/mnt/beegfs
|-- apps
|   |-- slurm
|   `-- spack
|-- home
|   |-- adigenova
|   |-- cbozo
|   |-- cgonzalez
|   |-- cmoraga
|   |-- cvalenzuela
|   |-- david
|   |-- duvan.henao
|   |-- evargas
|   |-- fgomez
|   |-- gcastillo
|   |-- gmunoz
|   |-- lreyes
|   |-- pcarrasco
|   |-- pjullian
|   |-- rvalenzuela
|   |-- scalderon
|   |-- spoblete
|   |-- vbucarey
|   |-- vgonzalez
|   |-- vverdugo
|   `-- wgalvez
`-- labs
    |-- AGENsLab
    |-- Appliedmath
    |-- DiGenomaLab
    |-- ESciences
    |-- FairComp
    |-- GranularLab
    |-- NLComp
    `-- PMPLAB
```

Kütral

Rendimiento teórico

- Procesadores (776)
  - 8.427 Tflops
  - **8.4 billones de operaciones de punto flotante por segundo.**
- RAM
  - 8.3 Tbites
- Almacenamiento
  - 194 Tb (39M de canciones)
- Dentro del top10 clúster en Chile.

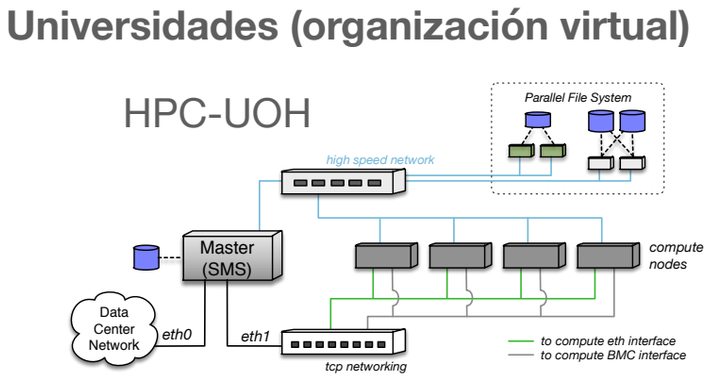


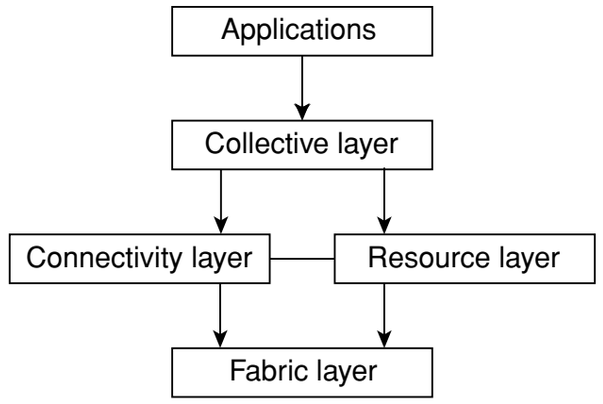
- **Realizar cálculos científicos**
- **Entrenar modelos de aprendizaje automático**
- **Simular fenómenos físicos**
- **Predecir y estudiar fenómenos meteorológicos**
- **Realizar estudios genómicos.**

Sistemas distribuidos

Tipos

- Sistemas de cómputo distribuido
  - <u>Clúster de cómputo</u>
    - Hardware similar
    - Red local de alta velocidad
    - Mismo sistema operativo
  - <u>Grid de computo</u>
    - Alto grado de heretogeneidad
    - Federación de sistemas de cómputo (clúster)





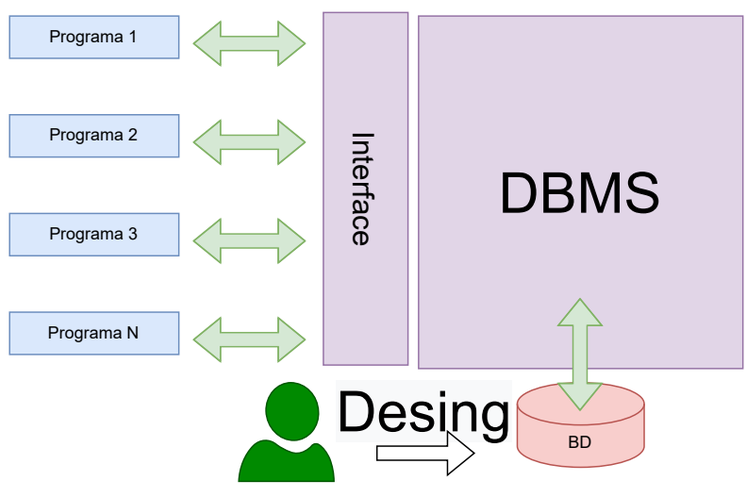
- <u>Fabric layer:</u>
  - <u>proporciona interfaces a los recursos locales en un sitio específico</u>
- <u>Connectivity layer</u>
  - <u>protocolos de comunicación para soportar transacciones de red que abarcan el uso de múltiples recursos.</u>
- <u>Resource layer</u>
  - <u>responsable de administrar un solo recurso</u>
- <u>Collective layer:</u>
  - <u>maneja el acceso a múltiples recursos y generalmente consiste en servicios para el descubrimiento de recursos, asignación y programación de tareas</u>

HTCondor Software Suite

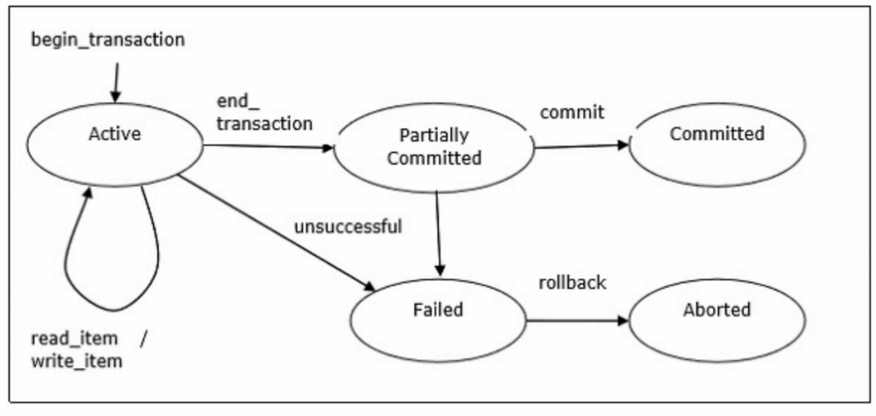
Sistemas distribuidos

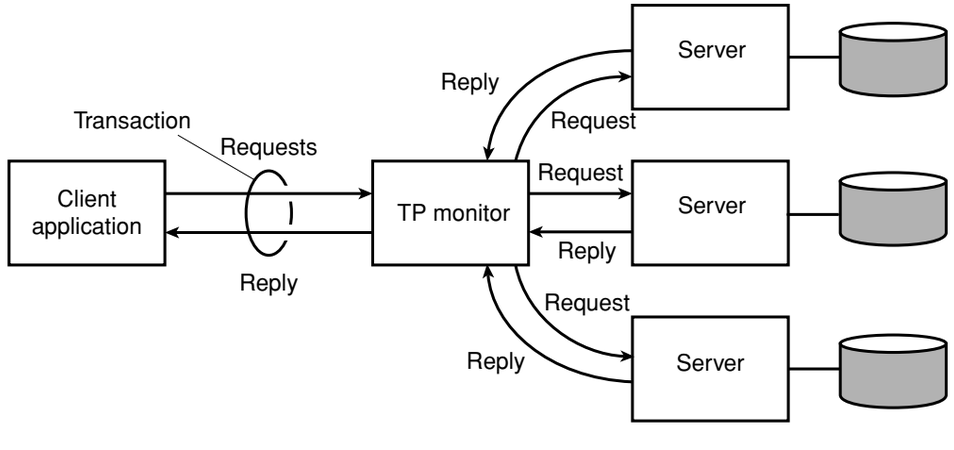
Tipos

- Sistemas de información distribuido
    - un servidor que ejecuta una aplicación (que a menudo incluye una base de datos) y la coloca a disposición de programas remotos, usuarios o clientes.



- Sistemas de procesamiento de transacciones
    - La idea clave es que se ejecutaran todas o ninguna de las solicitudes.
    - Propiedades ACID (Atomic, Consistent, Isolated, Durable)
    - Monitor de procesamiento de transacciones
        - Permite que una aplicación acceda a múltiples servidores/bases de datos mediante un modelo de programación transaccional.

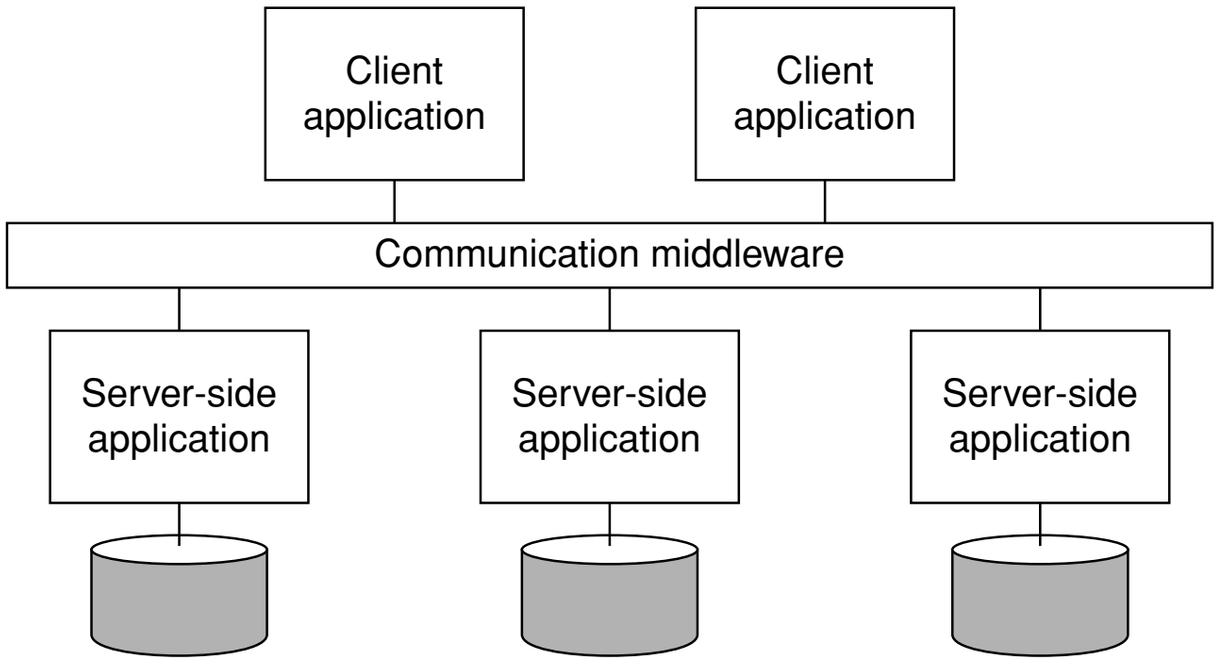




Sistemas distribuidos

Tipos

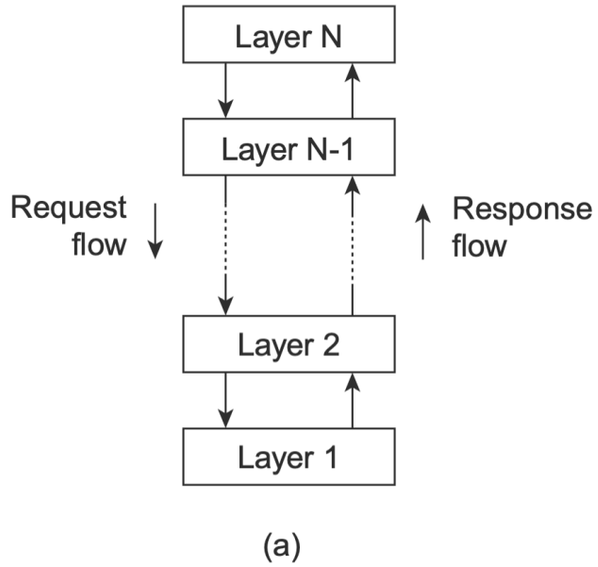
- Sistemas de información distribuido
  - Sistemas de procesamiento de transacciones
  - Sistemas de integración de aplicaciones.
    - Comunicación entre aplicaciones.
    - Idea: aplicaciones intercambian directamente información.
    - Metodos de lamadas remota (Resource Manager Interface)



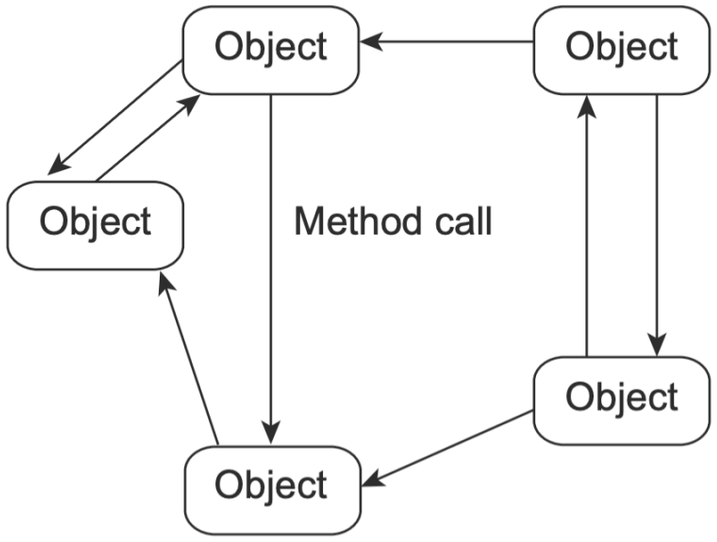
Sistemas distribuidos

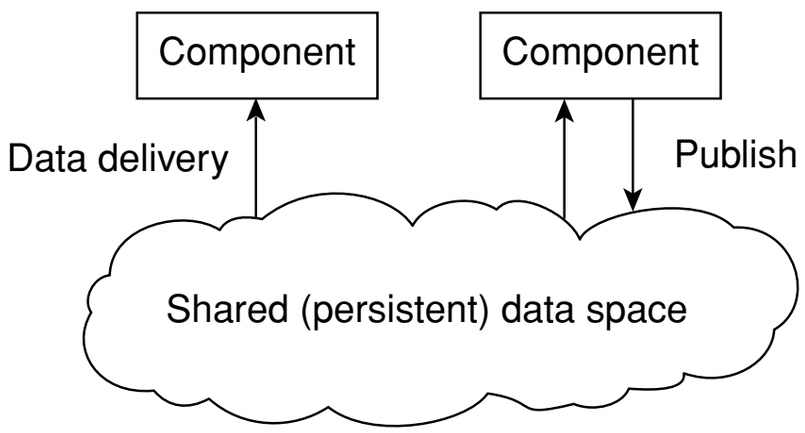
Arquitecturas

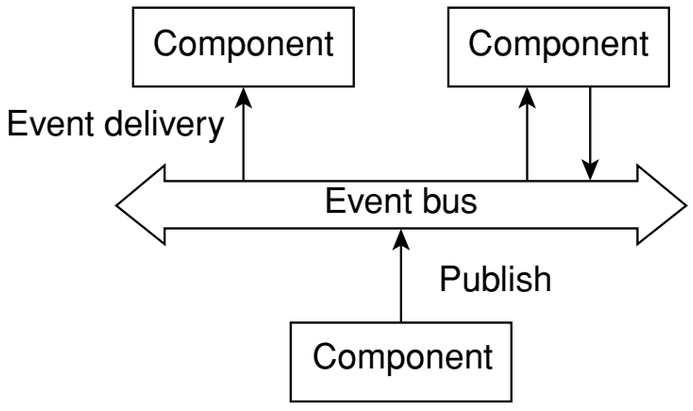
- Necesitamos definir cómo deben organizarse los diversos componentes de software y cómo deben interactuar.



(a)

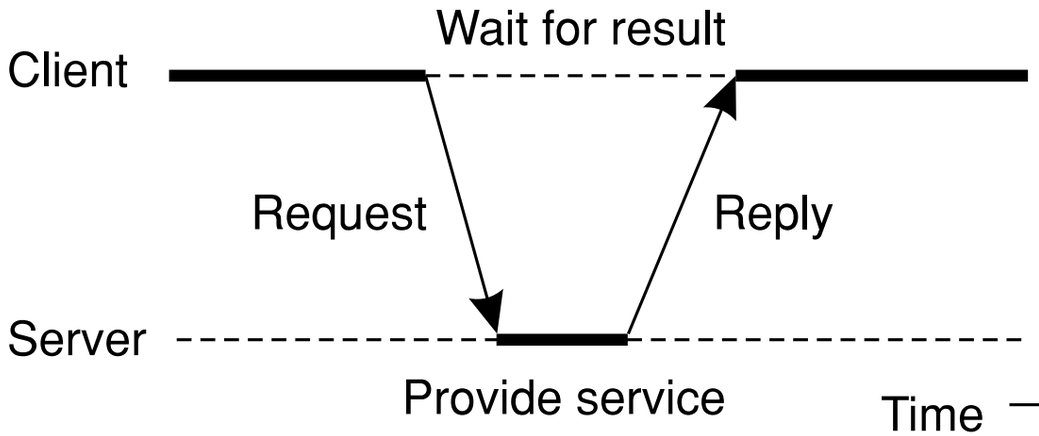


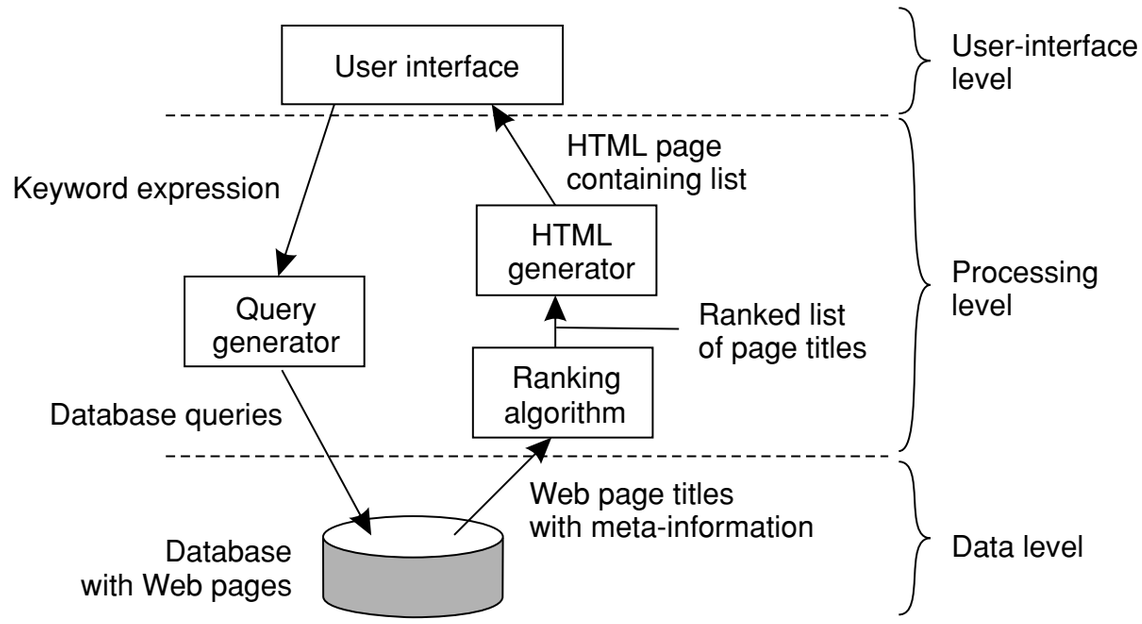


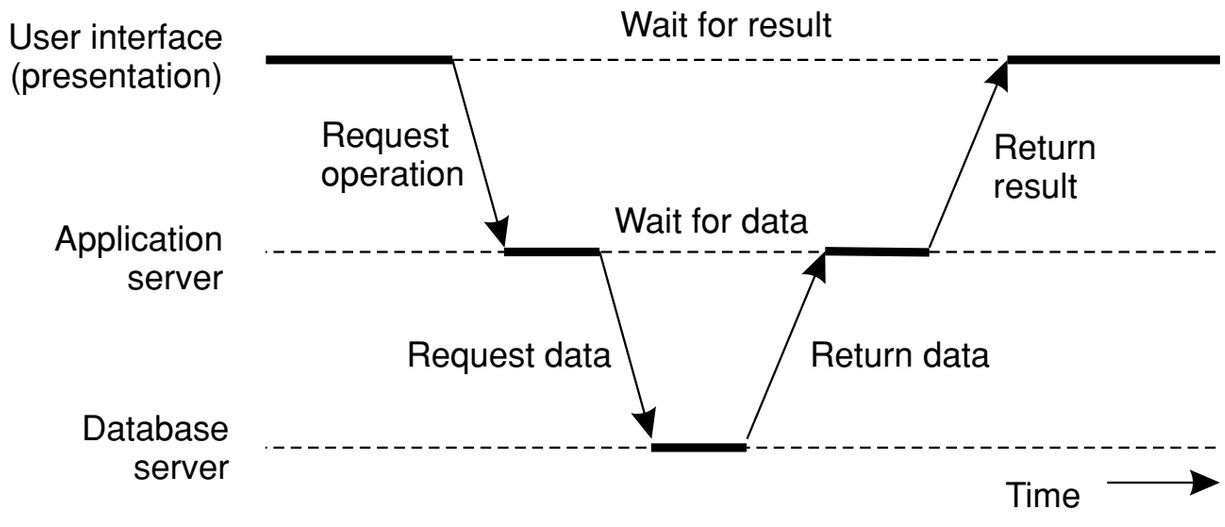


Sistemas distribuidos

Arquitecturas centralizadas

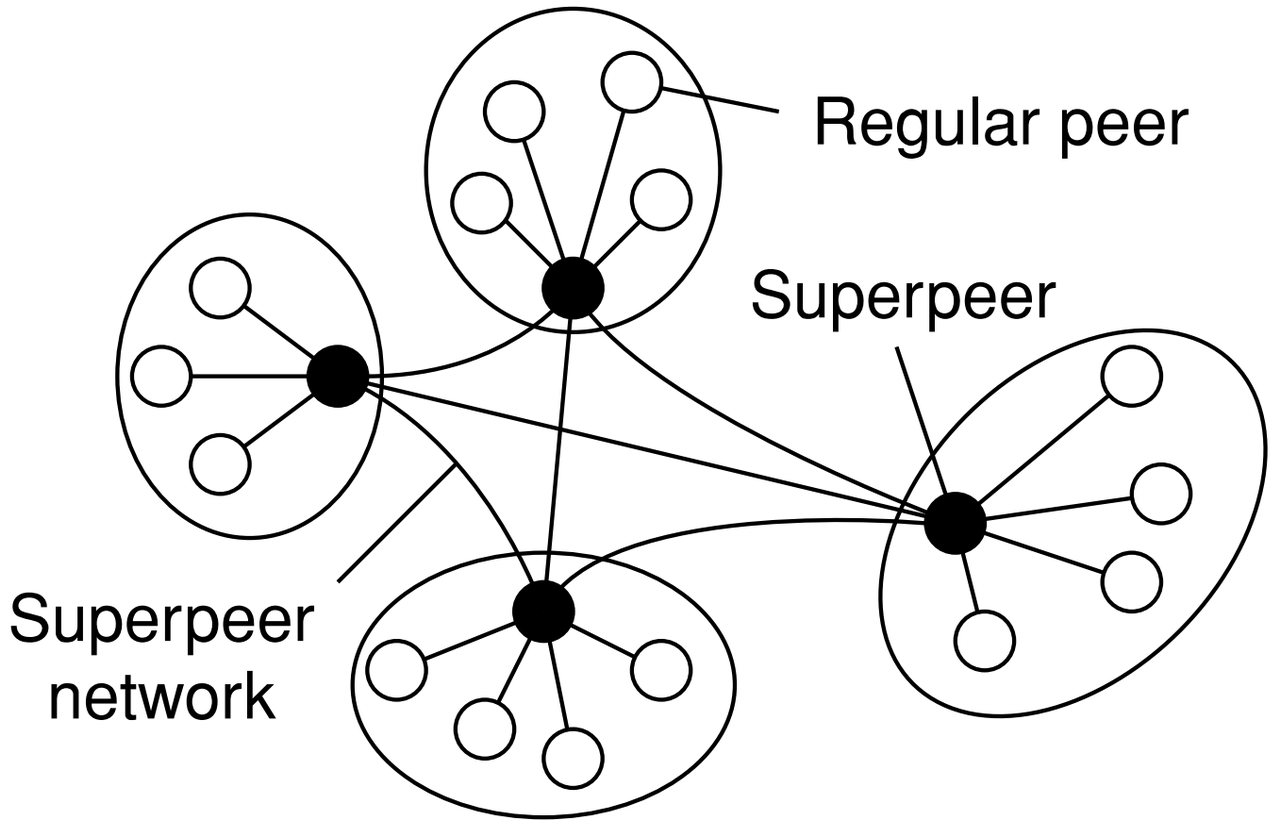




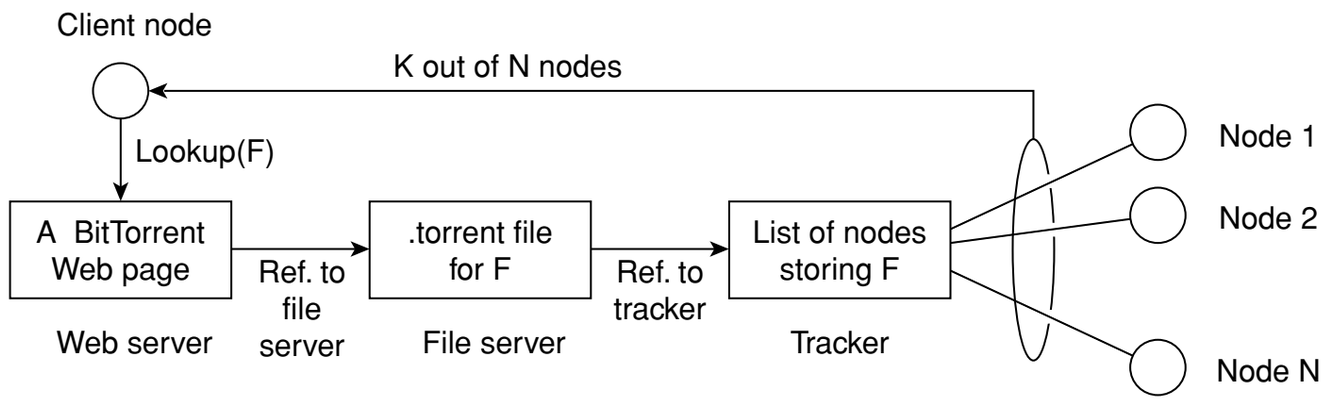


Sistemas distribuidos

Arquitecturas no-centralizadas



Hibridas



Linux

Linux

A operating system

User Processes

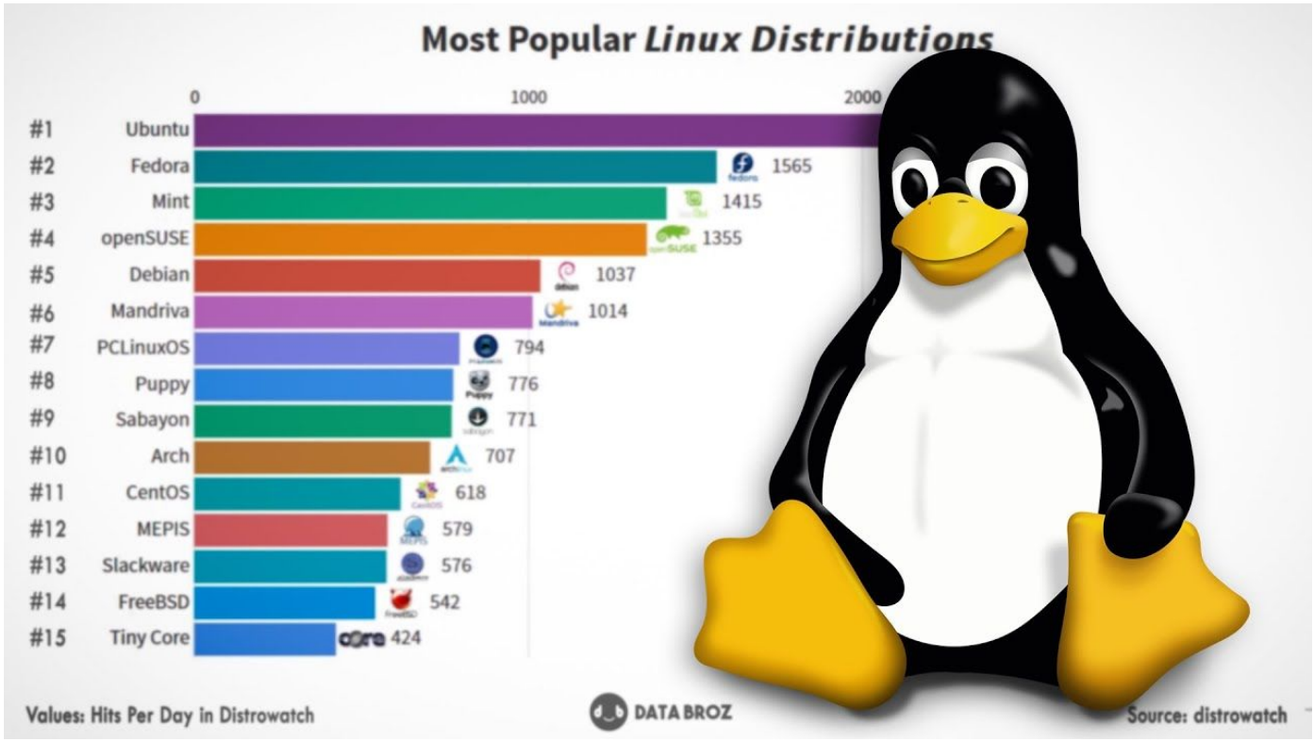
- Graphical User Interface
- Servers
- Shell

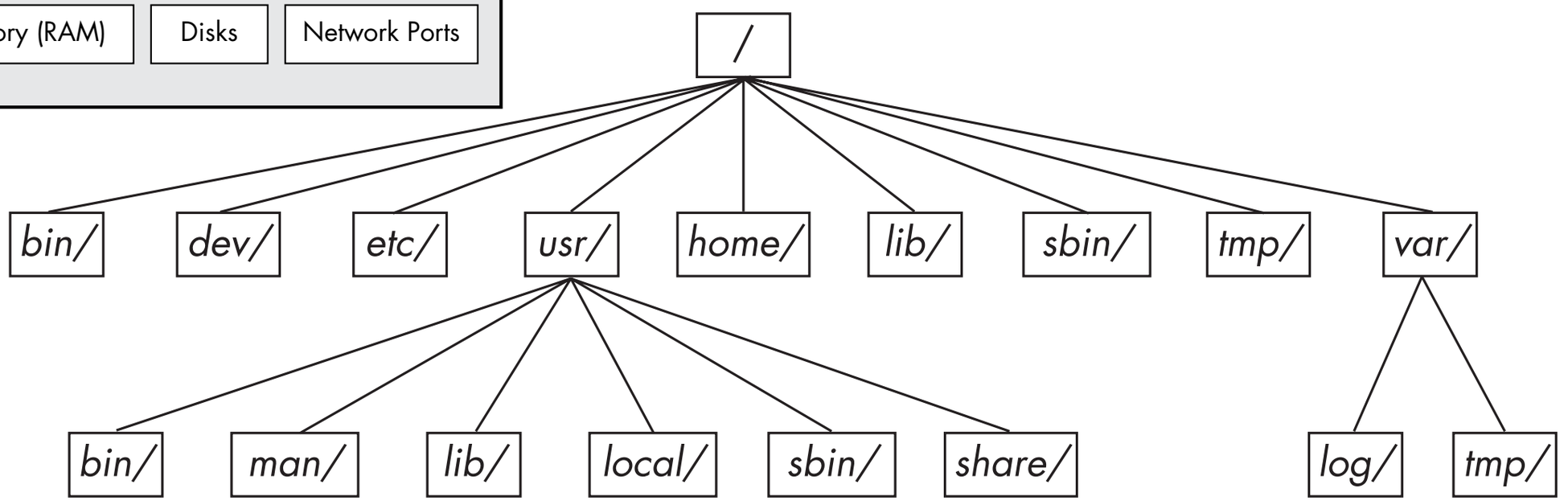
Linux Kernel

- System Calls
- Process Management
- Memory Management
- Device Drivers

Hardware

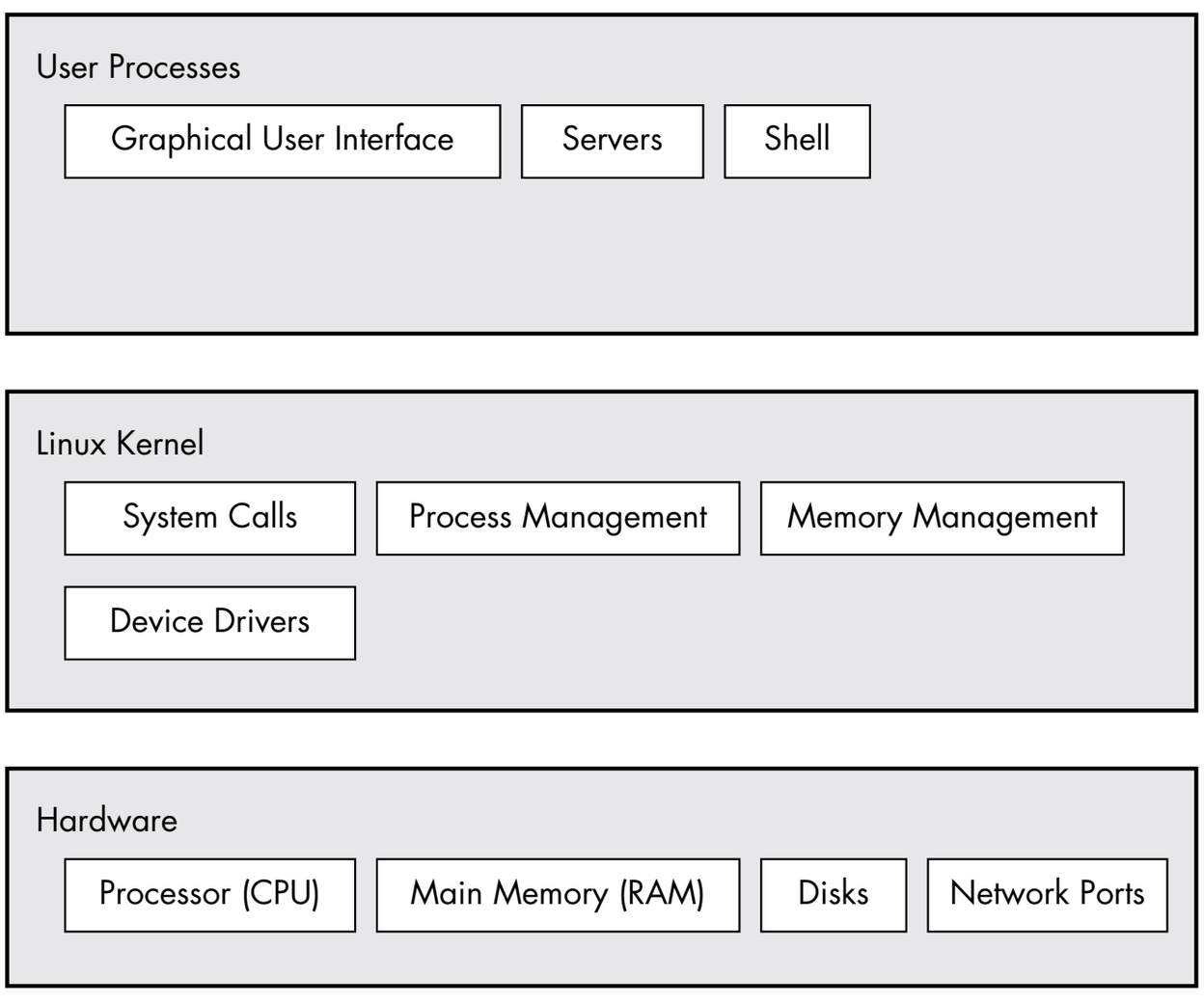
- Processor (CPU)
- Main Memory (RAM)
- Disks
- Network Ports



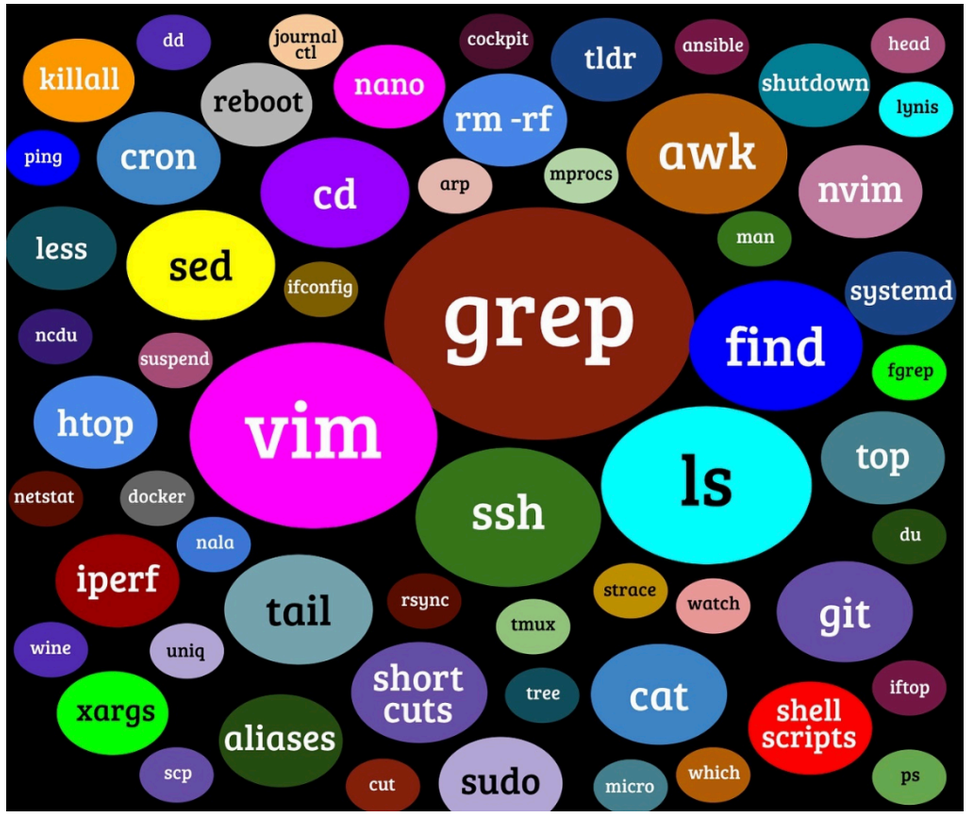


Linux

A operating system



- The *shell* is a program that runs commands.
- The *shell* also serves as a small programming environment.



- https://github.com/trinib/Linux-Bash-Commands

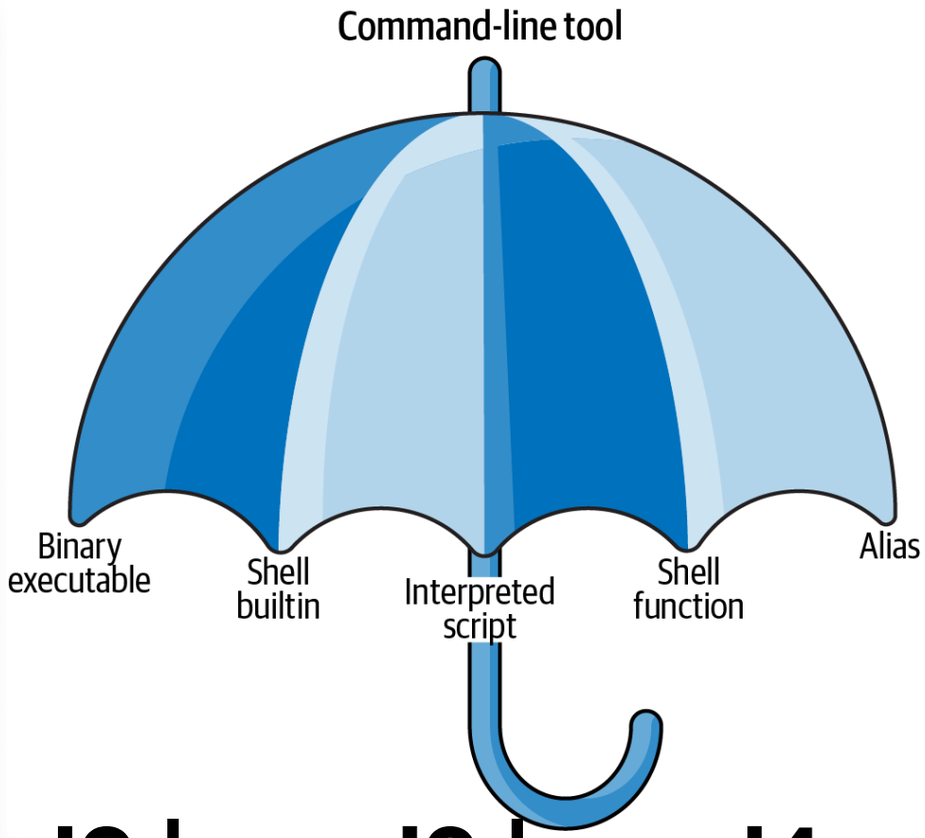
Linux

Shell command line

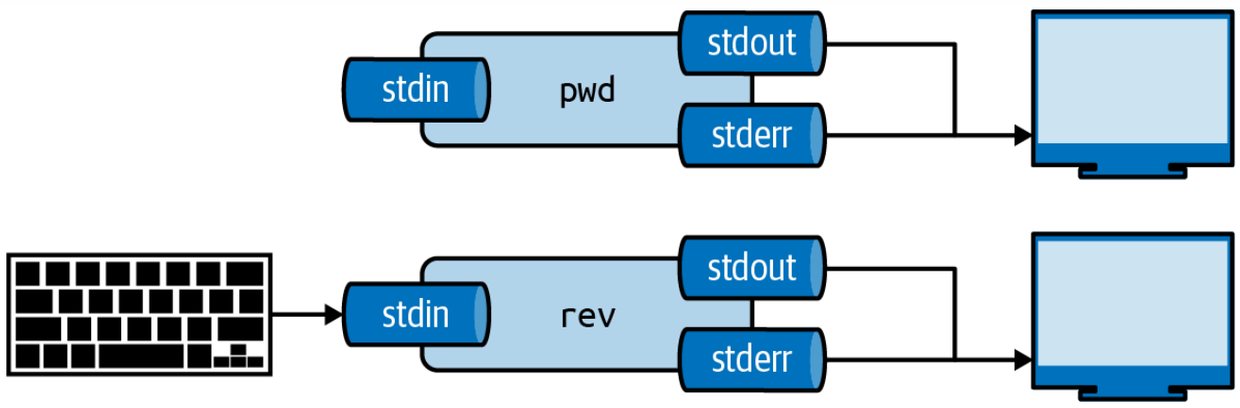
clases — adigenova@host04:~ — ssh adigenova@172.16.105.104 — 80×23

...@host04:~ — -bash ... ...R/pipelines — -bash ... ...ethylation — -bash ... ...trelka_pool — -bash ... ...ova@172.16.105.104 ...elka_pool] — -bash ... ...egfs/home — -bash ... +

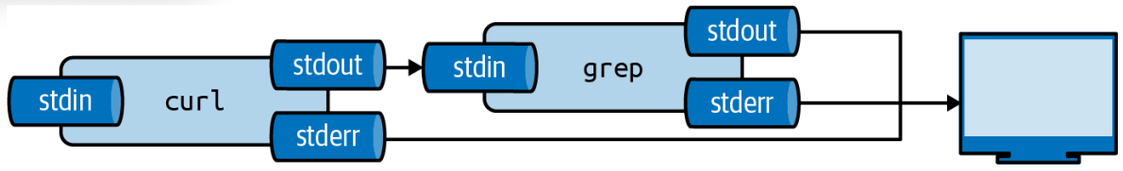
```
[adigenova@host04 ~]$ echo "The command line is the force DCBI" | cowsay -f tux
 ____________________________________
< The command line is the force DCBI >
 ------------------------------------
   \
    \
        .--.
       |o_o |
       |:_/ |
      //   \ \
     (|     | )
    /'\_   _/`\
    \___)=(___/

[adigenova@host04 ~]$
```



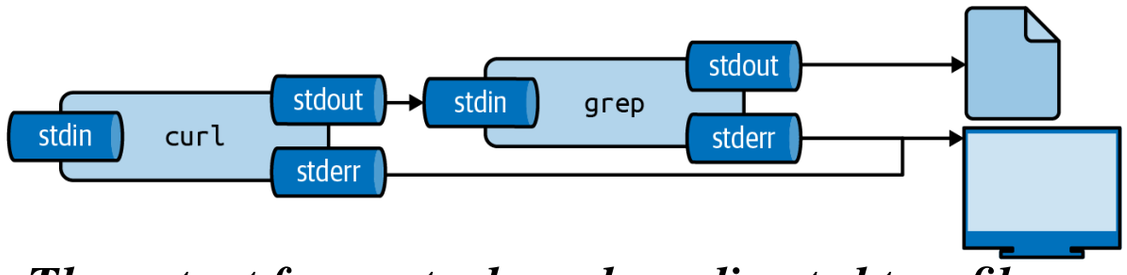
cmd1 | cmd2 | cmd3 | cmd4 ...



Every tool has three standard streams: standard input (stdin), standard output (stdout), and standard error (stderr)



The output from a tool can be piped to another tool



The output from a tool can be redirected to a file

Linux

Basic shell comands

Command Information

```
man chmod                    # Display page manual of a command
man -fl--whatis chmod        # Display short description about a command
man -kl--apropos permission  # Display all related commands from a specific keyw

chmod --help                 # Display usage options of a command
```

Command History

```
history                      # View all previous commands
history | grep foo           # View the commands using a specific word
history | head -nl--lines 3  # View the first 3 executed commands
history 3                    # View the last 3 executed commands
history -d 99                # Clear a command from a specific line
history -c                   # Clears all history commands
!!                           # Run the last command executed
```

Navigating Directories

```
pwd                 # Print current directory path
ls                  # List directories
ls -al--all         # List directories including hidden
ls -l               # List directories in long form
ls -t               # List directories by modification time, newest first
stat foo.txt        # List size, created and modified timestamps for a file
stat foo            # List size, created and modified timestamps for a directory
tree                # List directory and file tree
tree -a             # List directory and file tree including hidden
tree -d             # List directory tree

cd foo              # Go to foo sub-directory
cd                  # Go to home directory
cd ~                # Go to home directory
cd -                # Go to the previously chosen directory
pushd foo           # Go to foo sub-directory and add previous directory to stack
popd                # Go back to directory in stack saved by `pushd`
```

Creating Directories

```
mkdir foo                       # Create a directory
mkdir foo bar                   # Create multiple directories
mkdir -pl--parents foo/bar      # Create nested directory
mkdir -pl--parents {foo,bar}/baz # Create multiple nested directories
```

Moving Directories

```
cp -R | --recursive foo bar                  # Copy directory
mv foo bar                                   # Move directory

rsync -zl--compress -vl--verbose /foo /bar   # Copy directory, overwrites destination
rsync -avz /foo username@hostname:/bar       # Copy local directory to remote directory
rsync -avz username@hostname:/foo /bar       # Copy remote directory to local directory
```

Deleting Directories

```
rmdir foo                    # Delete non-empty directory
rm -rl--recursive foo        # Delete directory including contents
rm -rl--recursive -fl--force foo  # Delete directory including contents, ignore nonexistent files and never prompt
```

Linux

Basic shell comands

Creating Files

```
touch foo.txt             # Create file or update existing files modified timestamp
touch foo.txt bar.txt     # Create multiple files
touch {foo,bar}.txt       # Create multiple files
touch test{1..3}          # Create test1, test2 and test3 files
touch test{a..c}          # Create testa, testb and testc files

mktemp                    # Create a temporary file
```

Moving Files

```
cp foo.txt bar.txt                          # Copy file
mv foo.txt bar.txt                          # Move file

rsync -zl--compress -v /foo.txt /bar        # Copy file quickly if not changed
rsync -zl--compress -v /foo.txt /bar.txt    # Copy and rename file quickly if not changed
```

Deleting Files

```
rm foo.txt                # Delete file
rm -fl--force foo.txt     # Delete file, ignore nonexistent files and never prompt
```

Standard Output, Standard Error and Standard Input

```
echo "foo" > bar.txt              # Overwrite file with content
echo "foo" >> bar.txt             # Append to file with content

ls exists 1> stdout.txt           # Redirect the standard output to a file
ls noexist 2> stderror.txt        # Redirect the standard error output to a file
ls > out.txt 2>&1                 # Redirect standard output and error to a file
ls > /dev/null                    # Discard standard output and error

read foo                          # Read from standard input and write to the variable foo
```

Reading Files

```
cat foo.txt               # Print all contents
less foo.txt              # Print some contents at a time (g - go to top of file)
head foo.txt              # Print top 10 lines of file
tail foo.txt              # Print bottom 10 lines of file
tail -fl--follow foo.txt  # Print bottom 10 lines of file updating with new data
open foo.txt              # Open file in the default editor
wc foo.txt                # List number of lines words and characters in the file
```

Sorting Files

```
sort foo.txt                                # Sort file (ascending order)
sort -rl--reverse foo.txt                   # Sort file (descending order)
sort -nl--numeric-sort foo.txt              # Sort numbers instead of strings
sort -tl--field-separator: -k 3n /foo/foo.txt   # Sort by the third column of a file
```

- https://github.com/trinib/Linux-Bash-Commands

Linux

Basic shell comands

Finding Files

Find binary files for a command.

```
type -a wget                    # Display all locations of executable
which -a wget                   # Display all locations of executables
whereis wget                    # Find the binary, source, and manual page files
```

locate uses an index and is fast.

```
updatedb                        # Update the index

locate foo.txt                  # Find a file
locate --ignore-case            # Find a file and ignore case
locate f*.txt                   # Find a text file starting with 'f'
```

find doesn't use an index and is slow.

```
find /path -name foo.txt                # Find a file
find /path -iname foo.txt               # Find a file with case insensitiv
find /path -name "*.txt"                # Find all text files
find /path -name foo.txt -delete        # Find a file and delete it
find /path -type f -name foo.txt        # Find a file
find /path -type d -name foo            # Find a directory
find /path -type l -name foo.txt        # Find a symbolic link
find /path -type f -mtime +30           # Find files that haven't been modified in 30 days
find /path -type f -mtime +30 -delete   # Delete files that haven't been modified in 30 days
```

Find in Files

```
grep 'foo' /bar.txt                     # Search for 'foo' in file 'bar.txt'
grep 'foo' /bar -rl--recursive          # Search for 'foo' in directory 'bar'
grep 'foo' /bar -ll--files-with-matches # Show only files that match
grep 'foo' /bar -Ll--files-without-match  # Show only files that don't match
grep 'Foo' /bar -il--ignore-case        # Case insensitive search
grep 'foo' /bar -xl--line-regexp        # Match the entire line
grep 'foo' /bar -vl--invert-match       # Show only lines that don't match
grep 'foo' /bar -cl--count              # Count the number lines that match
grep 'foo' /bar -nl--line-number        # Add line numbers
grep 'foo' /bar --colour                # Add colour to output
grep 'foo\|bar' /baz -R                 # Search for 'foo' or 'bar' in directory 'baz'
```

Replace in Files

```
sed 's/fox/bear/g' foo.txt                  # Replace fox with bear in foo.txt and output to console
sed 's/fox/bear/gi' foo.txt                 # Replace fox (case insensitive) with bear in foo.txt
sed 's/red fox/blue bear/g' foo.txt
sed 's/fox/bear/g' foo.txt > bar.txt        # Replace fox with bear in foo.txt and save in bar.txt
sed -il--in-place 's/fox/bear/g' foo.txt    # Replace fox with bear and overwrite foo.txt
sed -il--in-place '10s/find/replace/' foo.txt   # Replace the 10th line of the file
sed -il--in-place '10,20s/find/replace/' foo.txt  # Replace in the file 10-20 lines
```

Symbolic Links

```
ln -sl--symbolic foo bar        # Create a link 'bar' to the 'foo' folder
ls -l                           # Show where symbolic links are pointing
```

Linux

Basic shell comands

Disk Usage

```
df                          # List disks, size, used and available space
df -hl--human-readable  # human readable format

du                         # List current directory, subdirectories and file sizes
du /foo/bar                # List specified directory, subdirectories and file sizes
du -dl--max-depth       # List current directory, subdirectories and file sizes within the max depth
du -d 0                    # List current directory size
```

Memory Usage

```
free                # Show memory usage
free -hl--human        # Show human readable memory usage
free -hl--human --si   # Show human readable memory usage in power of 1000 instead o
free -sl--seconds 5    # Show memory usage and update continuously every five seconds
```

Shutdown and Reboot

```
shutdown                  # Shutdown in 1 minute
shutdown now              # Immediately shut down
shutdown +5               # Shutdown in 5 minutes

shutdown -rl--reboot         # Reboot in 1 minute
shutdown -rl--reboot now     # Immediately reboot
shutdown -rl--reboot +5      # Reboot in 5 minutes
shutdown -c               # Cancel a shutdown or reboot

reboot                    # Reboot now
reboot -f                 # Force a reboot
```

Identifying Processes

```
top              # List all processes interactively
htop             # List all processes interactively
ps ax            # List all processes
pidof foo        # Return the PID of all foo processes

CTRL+Z           # Suspend a process running in the foreground
bg               # Resume a suspended process and run in the background
fg               # Bring the last background process to the foreground
fg 1             # Bring the background process with the PID to the foreground

sleep 30         # Sleep for 30 seconds and move the process into the backgro
jobs             # List all background jobs
jobs -p          # List all background jobs with their PID

lsof             # List all open files and the process using them
lsof -itcp:4000  # Return the process listening on port 4000
```

Killing Processes

```
CTRL+C          # Kill a process running in the foreground
kill PID        # Shut down process by PID gracefully. Sends TERM signal.
kill -9 PID     # Force shut down of process by PID. Sends SIGKILL signal.
pkill foo       # Shut down process by name gracefully. Sends TERM signal.
pkill -9 foo    # force shut down process by name. Sends SIGKILL signal.
killall foo     # Kill all process with the specified name gracefully.
```

HTTP Requests

```
wget https://example.com/file.txt                                  # Download a file to the current directory
wget -Ol--output-document foo.txt https://example.com/file.txt   # Output to a file with the specified name
```

Linux

Basic shell comands

User Management

```
sudo su                                  # Switch to root user
sudo foo                                 # Execute commands(has permission denied) as the root user
sudo nano /foo/foo.txt                   # Open directories and files(is not writable) as the root user
su username                              # Switch to a different user

passwd                                   # To change the password of a user
adduser username                         # To add a new user
userdel username                         # To remove user
userdel -rl--remove username             # To remove user with home directory and mail spool
usermod -al--append -Gl--groups GROUPNAME USERNAME # To add a user to a group
deluser USER GROUPNAME                   # To remove a user from a group

last                                     # Display information of all the users logged in
last username                            # Display information of a particular user
w                                        # Display who is online
```

System Information

```
uname -s                 # Print kernel name
uname -r                 # Print kernel release
uname -m                 # Print Architecture
uname -o                 # Print Operating System
uname -a                 # Print all Systen info

lsb_release -a           # Print distribution-specific information
dpkg --print-architecture # Print-architecture by name

cat /proc/cpuinfo        # Show cpu info
cat /proc/meminfo        # Show memory info
```

Terminal Multiplexers

Start multiple terminal sessions. Active sessions persist r

```
tmux             # Start a new session (CTRL-b + d to detach)
tmux ls          # List all sessions
tmux attach -t 0 # Reattach to a session

screen           # Start a new session (CTRL-a + d to detach)
screen -S foo    # Start a new named session
screen -ls       # List all sessions
screen -R 31166  # Reattach to a session
```

Secure Shell Protocol (SSH)

```
ssh hostname                 # Connect to hostname using your current user name (p 22)
ssh -i foo.pem hostname      # Connect to hostname using the identity file
ssh user@hostname            # Connect to hostname using the user over the default SSH port 22
ssh user@hostname -p 8765    # Connect to hostname using the user over a custom port
ssh ssh://user@hostname:8765 # Connect to hostname using the user over a custom port
```

Secure Copy

```
scp foo.txt ubuntu@hostname:/home/ubuntu          # Copy foo.txt into the specified remote directory
scp ubuntu@hostname:/home/ubuntu/foo.txt .    # Copy foo.txt from the specified remote directory
```

https://linuxupskillchallenge.org/

Visita a Cluster UOH

Consultas?

Consultas o comentarios?

Muchas gracias