Lecture _3

LINUX essentials

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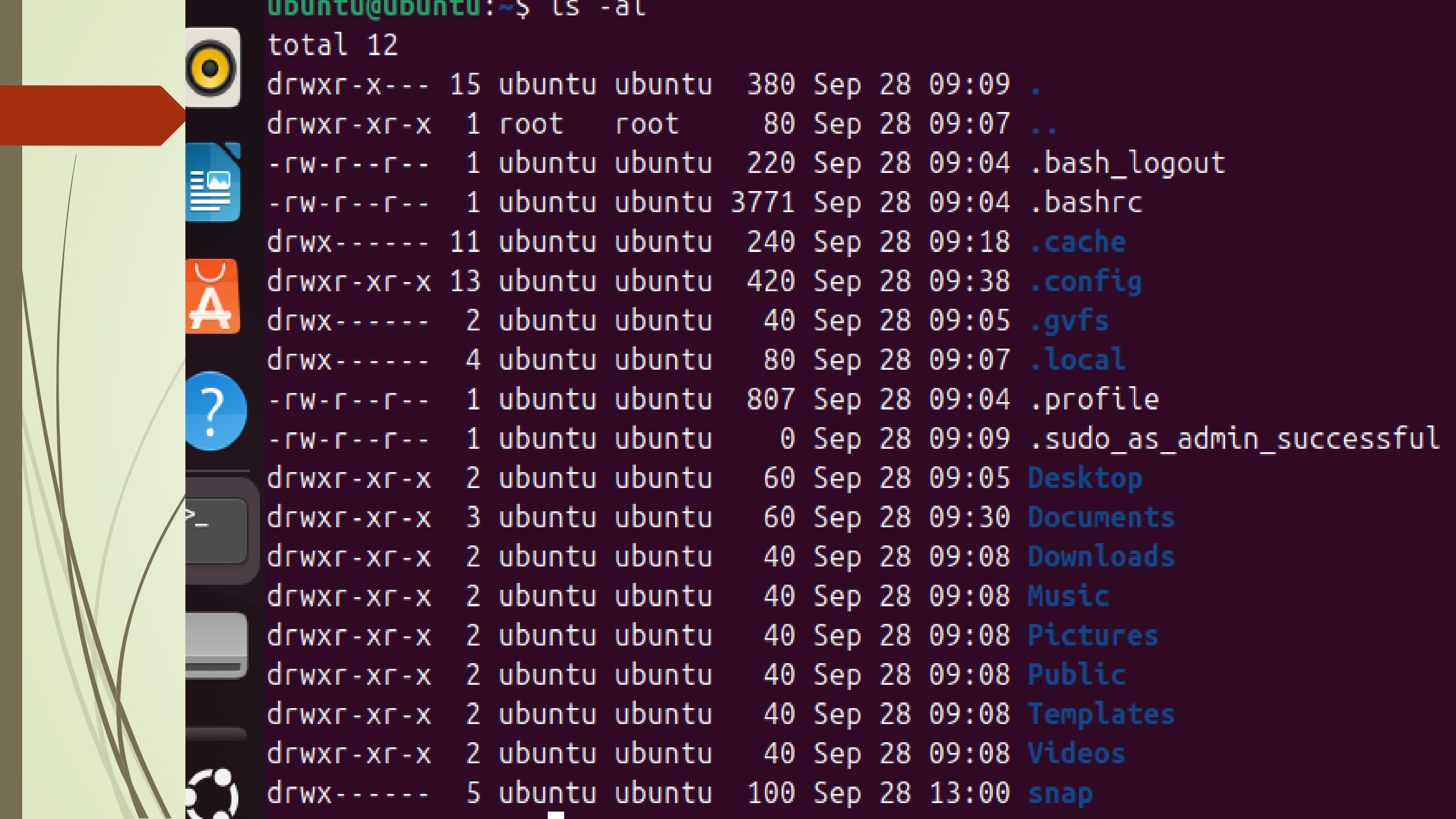
Files

- The ls command is used to list the contents of a directory. You've already seen it used a few times before in examples, but this page will help ensure you are comfortable with its use.
- The ls command is one of the most used commands in the Linux terminal to display the files and directories or path in the terminal. So, using the ls command is a basic skill for navigating the Linux file system, handling files, and managing directories.

- To learn the details about a file, such as the type of file, the permissions, ownerships or the timestamp, perform a long listing using the -l option to the ls command. Below, a listing of the /var/log directory is used as an example, since it provides a variety of output:

```
ubuntu@ubuntu:~$ ls  -l /var/log
total 2160
lrwxrwxrwx  1 root             root                  39 Aug  5 16:48 README -> ../../usr/share/doc/systemd/README.logs
-rw-r--r--  1 root             root               44057 Sep 28 09:15 Xorg.0.log
-rw-r--r--  1 root             root               24670 Aug  5 17:38 alternatives.log
-rw-r-----  1 root             adm                    0 Sep 28 09:06 apport.log
drwxr-xr-x  1 root             root                  53 Aug  5 17:38 apt
-rw-r-----  1 syslog           adm                10581 Sep 28 10:30 auth.log
-rw-------  1 root             root               15189 Sep 28 09:07 boot.log
-rw-r--r--  1 root             root              118497 Aug  5 16:48 bootstrap.log
-rw-rw----  1 root             utmp                   0 Aug  5 16:48 btmp
-rw-r--r--  1 root             root                2023 Sep 28 09:05 casper.log
-rw-r--r--  1 root             root                4187 Sep 28 09:13 cloud-init-output.log
-rw-r-----  1 syslog           adm                50904 Sep 28 09:13 cloud-init.log
drwxr-xr-x  1 root             root                  60 Sep 28 09:07 cups
drwxr-xr-x  2 cups-browsed     lpadmin                3 Aug  5 16:53 cups-browsed
drwxr-xr-x  2 root             root                   3 Jul 25 16:08 dist-upgrade
-rw-r-----  1 root             adm               132917 Sep 28 09:06 dmesg
-rw-r--r--  1 root             root             1066086 Aug  5 17:38 dpkg.log
-rw-r--r--  1 root             root                   0 Aug  5 16:48 faillog
-rw-r--r--  1 root             root                5010 Aug  5 17:31 fontconfig.log
drwx--x--x  2 root             gdm                   40 Sep 28 09:07 gdm3
-rw-r--r--  1 root             root                1522 Sep 28 09:06 gpu-manager.log
drwxr-xr-x  3 root             root                  26 Aug  5 16:50 hp
drwxrwx---  3 root             adm                  180 Sep 28 09:13 installer
drwxr-sr-x+ 1 root             systemd-journal       60 Sep 28 09:05 journal
-rw-r-----  1 syslog           adm               172781 Sep 28 09:14 kern.log
-rw-rw-r--  1 root             utmp                   0 Aug  5 16:48 lastlog
drwxr-xr-x  2 root             root                   3 May 30 15:24 openvpn
```


ubuntu@ubuntu:~$ ls -al
total 12
drwxr-x--- 15 ubuntu ubuntu 380 Sep 28 09:09 .
drwxr-xr-x 1 root   root   80 Sep 28 09:07 ..
-rw-r--r-- 1 ubuntu ubuntu 220 Sep 28 09:04 .bash_logout
-rw-r--r-- 1 ubuntu ubuntu 3771 Sep 28 09:04 .bashrc
drwx------ 11 ubuntu ubuntu 240 Sep 28 09:18 .cache
drwxr-xr-x 13 ubuntu ubuntu 420 Sep 28 09:38 .config
drwx------ 2 ubuntu ubuntu   40 Sep 28 09:05 .gvfs
drwx------ 4 ubuntu ubuntu   80 Sep 28 09:07 .local
-rw-r--r-- 1 ubuntu ubuntu 807 Sep 28 09:04 .profile
-rw-r--r-- 1 ubuntu ubuntu   0 Sep 28 09:09 .sudo_as_admin_successful
drwxr-xr-x 2 ubuntu ubuntu   60 Sep 28 09:05 Desktop
drwxr-xr-x 3 ubuntu ubuntu   60 Sep 28 09:30 Documents
drwxr-xr-x 2 ubuntu ubuntu   40 Sep 28 09:08 Downloads
drwxr-xr-x 2 ubuntu ubuntu   40 Sep 28 09:08 Music
drwxr-xr-x 2 ubuntu ubuntu   40 Sep 28 09:08 Pictures
drwxr-xr-x 2 ubuntu ubuntu   40 Sep 28 09:08 Public
drwxr-xr-x 2 ubuntu ubuntu   40 Sep 28 09:08 Templates
drwxr-xr-x 2 ubuntu ubuntu   40 Sep 28 09:08 Videos
drwx------ 5 ubuntu ubuntu 100 Sep 28 13:00 snap

File Type

```
-rw-r--r-- 1 root   root  18047 Dec 20  2017 alternatives.log

drwxr-x--- 2 root   adm    4096 Dec 20  2017 apache2
```

- Each line corresponds to a file contained within the directory. The information can be broken down into fields separated by spaces.
- The first file alternatives.log is a regular file -, while the second file apache2 is a directory d.

The first field actually contains ten characters, where the first character indicates the type of file and the next nine specify permissions. The file types are:

Symbol	File Type	Description
d	directory	A file used to store other files.
-	regular file	Includes readable files, images files, binary files, and compressed files.
l	symbolic link	Points to another file.
s	socket	Allows for communication between processes.

p	pipe	Allows for communication between processes.
b	block file	Used to communicate with hardware.
c	character file	Used to communicate with hardware.

Understanding the output of `ls -al`

```
$ ls -al .
total 24
drwxrwxr-x 2 rzon scinet  4096 Oct 11 00:17 .
drwxrwxr-x 4 rzon scinet  4096 Oct 11 00:17 ..
-rw-rw-r-- 1 rzon scinet  6251 Oct 11 10:07 slide1.pdf
-rw-rw-r-- 1 rzon ccstaff 8245 Oct 11 10:08 slide2.pdf
```

This is a table with one row per file or directory with the following fields:

1. Cryptic-looking permission strings that will be explained soon;
2. A number showing how many places in the file system link to it;
3. The owner of the file or directory;
4. The group membership of the file or directory;
5. The size of a file;
6. Its date of last modification;
7. Its name.

- The **number after the permissions** shows how many directory entries (names) are pointing to the same inode.
- **Inode** → stores metadata (permissions, timestamps, link count, etc.) and pointers to the file's data blocks.

File Size

```
-rw-r----- 1 syslog adm    19573 Oct  2 22:57 syslog
```

Directories and larger files may be shown in kilobytes since displaying their size in bytes would present a very large number. Therefore, in the case of a directory, it might actually be a multiple of the block size used for the file system. Block size is the size of a series of data stored in the filesystem.

Permission	Effects on File	Effects on Directory
read (`r`)	Allows for file contents to be read or copied.	Without execute permission on the directory, allows for a non-detailed listing of files. With execute permission, `ls -l` can provide a detailed listing.
write (`w`)	Allows for contents to be modified or overwritten. Allows for files to be added or removed from a directory.	For this permission to work, the directory must also have execute permission.
execute (`x`)	Allows for a file to be run as a process, although script files require read permission, as well.	Allows a user to change to the directory if parent directories have execute permission as well.

Permissions

drwxrwxrwx (i.e. file permissions)

```
$ ls -al .
total 24
drwxrwxr-x 2 rzon scinet  4096 Oct 11 00:17 .
drwxrwxr-x 4 rzon scinet  4096 Oct 11 00:17 ..
-rw-rw-r-- 1 rzon scinet  6251 Oct 11 10:07 slide1.pdf
-rw-rw-r-- 1 rzon ccstaff 8245 Oct 11 10:08 slide2.pdf
```

There are 10 characters in the first column that represent the permissions set for this file.

The first character is `d` is it's a directory, `l` if it's a link, otherwise `-`.

The next three are the permission for the user, i.e., the owner.
They can be `rwx`, for read, write, and execute permission.
If a permission is not "set", the character at its position is `-`.

The following three are the permissions for members of the group to which the file belongs.

The final three are the permissions for others.

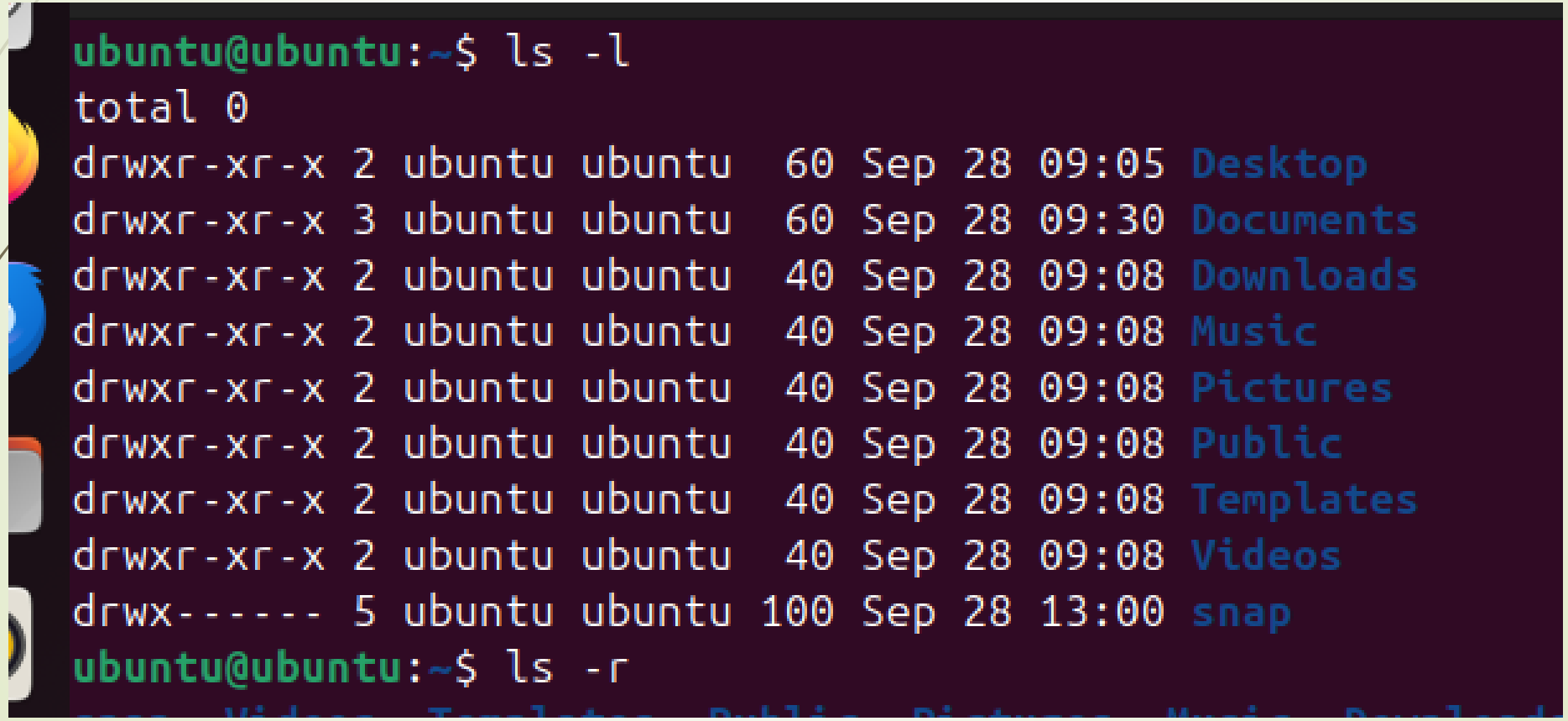
```
$ ls -al .
total 24
drwxrwxr-x 2 rzon scinet  4096 Oct 11 00:17 .
drwxrwxr-x 4 rzon scinet  4096 Oct 11 00:17 ..
-rw-rw-r-- 1 rzon scinet  6251 Oct 11 10:07 slide1.pdf
-rw-rw-r-- 1 rzon ccstaff 8245 Oct 11 10:08 slide2.pdf
```

Understand what different users are allowed to do with these files.

- `.` and `..` are directories (in fact, the current directory and its parent). They can be written to, read from, and executed by the user, or anyone in the **`scinet`** group. Others can only read and execute.
- **`slide1.pdf`** is not a directory, and cannot be executed, but can be written to and read from by **`rzon`** and members of the **`scinet`** group, and read by others.
- Similar for **`slide2.pdf`**, but writing is restricted to members of the **`ccstaff`** group.

Sorting

- By default, the output of the ls command is sorted alphabetically by **filename**. It can sort by other methods as well.



--help option

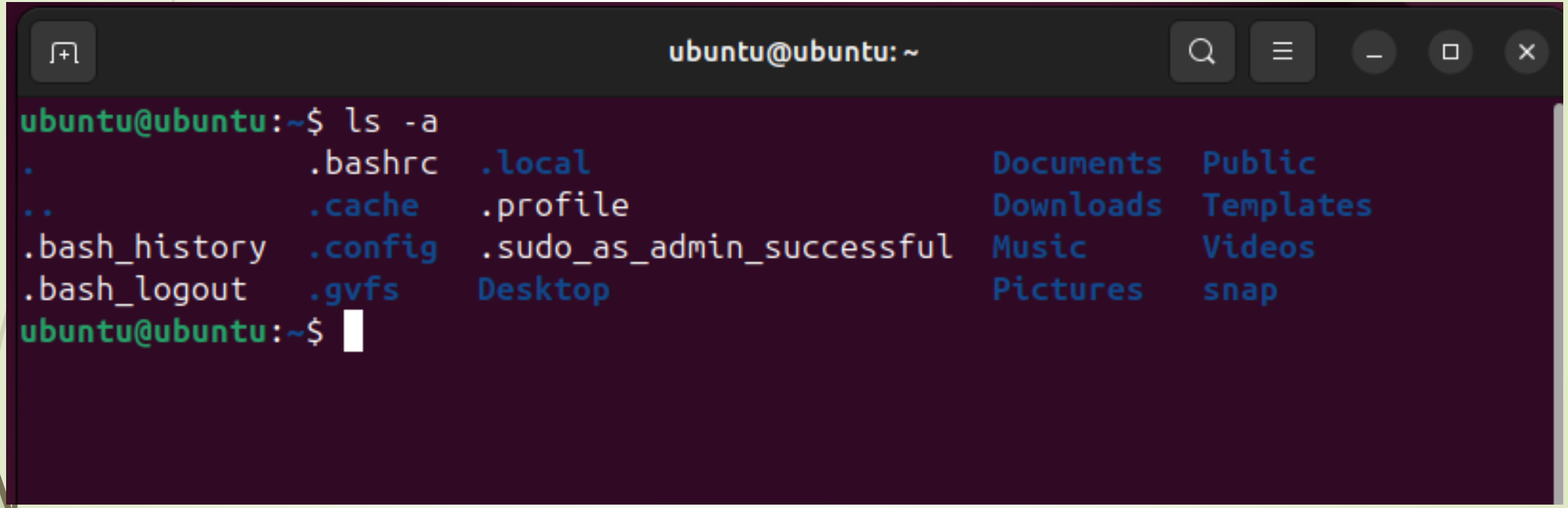
```
ubuntu@ubuntu:~$ ls  --help
Usage: ls [OPTION]... [FILE]...
List information about the FILEs (the current directory by default).
Sort entries alphabetically if none of -cftuvSUX nor --sort is specified.

Mandatory arguments to long options are mandatory for short options too.
  -a, --all                  do not ignore entries starting with .
  -A, --almost-all           do not list implied . and ..
      --author               with -l, print the author of each file
  -b, --escape               print C-style escapes for nongraphic characters
      --block-size=SIZE      with -l, scale sizes by SIZE when printing them;
                             e.g., '--block-size=M'; see SIZE format below

  -B, --ignore-backups       do not list implied entries ending with ~
  -c                         with -lt: sort by, and show, ctime (time of last
                             change of file status information);
                             with -l: show ctime and sort by name;
                             otherwise: sort by ctime, newest first

  -C                         list entries by columns
      --color[=WHEN]         color the output WHEN; more info below
  -d, --directory            list directories themselves, not their contents
  -D, --dired                generate output designed for Emacs' dired mode
  -f                         list all entries in directory order
```

The option **-a** means **“all”**, so it shows **all files**, including **hidden files** (those starting with a .).



The -t option will sort the files by timestamp

```
ubuntu@ubuntu:~$ ls -l -t
total 0
drwx------ 5 ubuntu ubuntu 100 Sep 28 13:00 snap
drwxr-xr-x 3 ubuntu ubuntu  60 Sep 28 09:30 Documents
drwxr-xr-x 2 ubuntu ubuntu  40 Sep 28 09:08 Music
drwxr-xr-x 2 ubuntu ubuntu  40 Sep 28 09:08 Pictures
drwxr-xr-x 2 ubuntu ubuntu  40 Sep 28 09:08 Videos
drwxr-xr-x 2 ubuntu ubuntu  40 Sep 28 09:08 Downloads
drwxr-xr-x 2 ubuntu ubuntu  40 Sep 28 09:08 Public
drwxr-xr-x 2 ubuntu ubuntu  40 Sep 28 09:08 Templates
drwxr-xr-x 2 ubuntu ubuntu  60 Sep 28 09:05 Desktop
ubuntu@ubuntu:~$
```

The -r option with list the files in reverse alphabetical order

```
ubuntu@ubuntu:~$ ls -l -r
total 0
drwx------ 5 ubuntu ubuntu 100 Sep 28 13:00 snap
drwxr-xr-x 2 ubuntu ubuntu  40 Sep 28 09:08 Videos
drwxr-xr-x 2 ubuntu ubuntu  40 Sep 28 09:08 Templates
drwxr-xr-x 2 ubuntu ubuntu  40 Sep 28 09:08 Public
drwxr-xr-x 2 ubuntu ubuntu  40 Sep 28 09:08 Pictures
drwxr-xr-x 2 ubuntu ubuntu  40 Sep 28 09:08 Music
drwxr-xr-x 2 ubuntu ubuntu  40 Sep 28 09:08 Downloads
drwxr-xr-x 3 ubuntu ubuntu  60 Sep 28 09:30 Documents
drwxr-xr-x 2 ubuntu ubuntu  60 Sep 28 09:05 Desktop
```

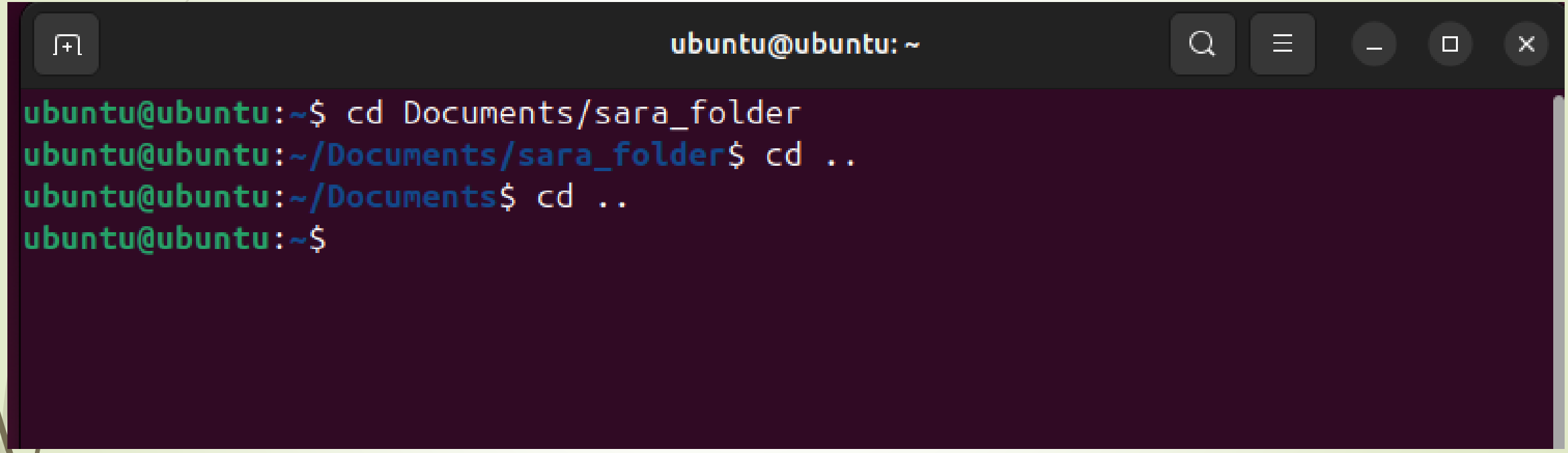
Shortcuts

The .. Characters or .. **Parent Directory**

- Regardless of which directory you are in, .. always represents one directory higher relative to the current directory, sometimes referred to as the parent directory.

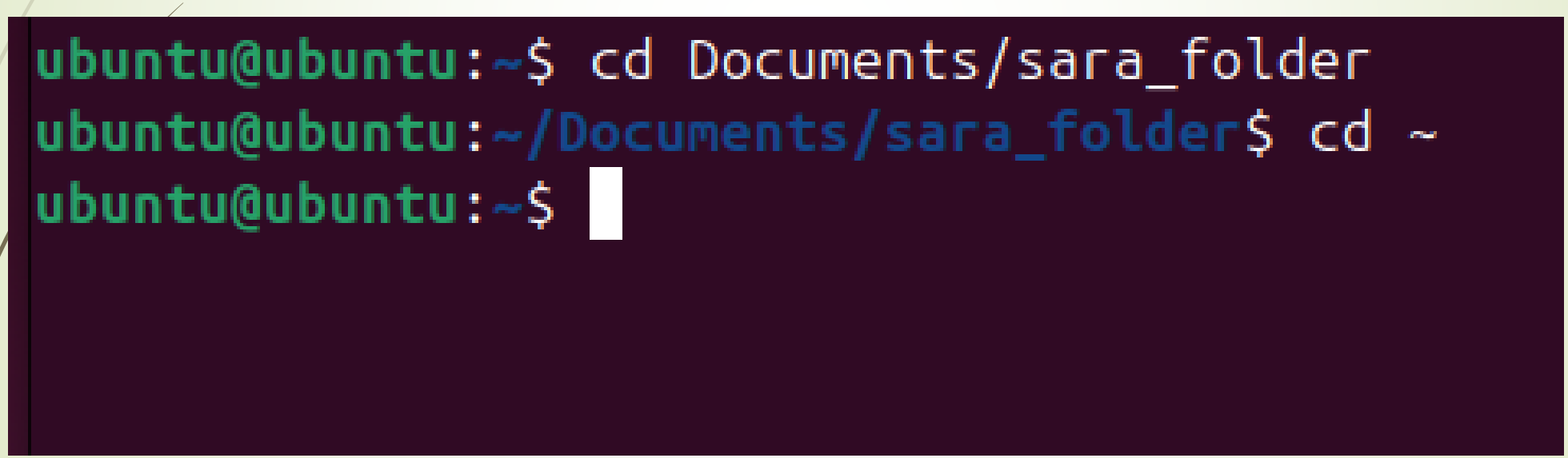
- The double period or "double dot" (..) represents the parent directory of your current one. You can use this to move up one level in the directory tree.

To move from the **sara_folder** directory back to the **main** directory(**ubuntu**):



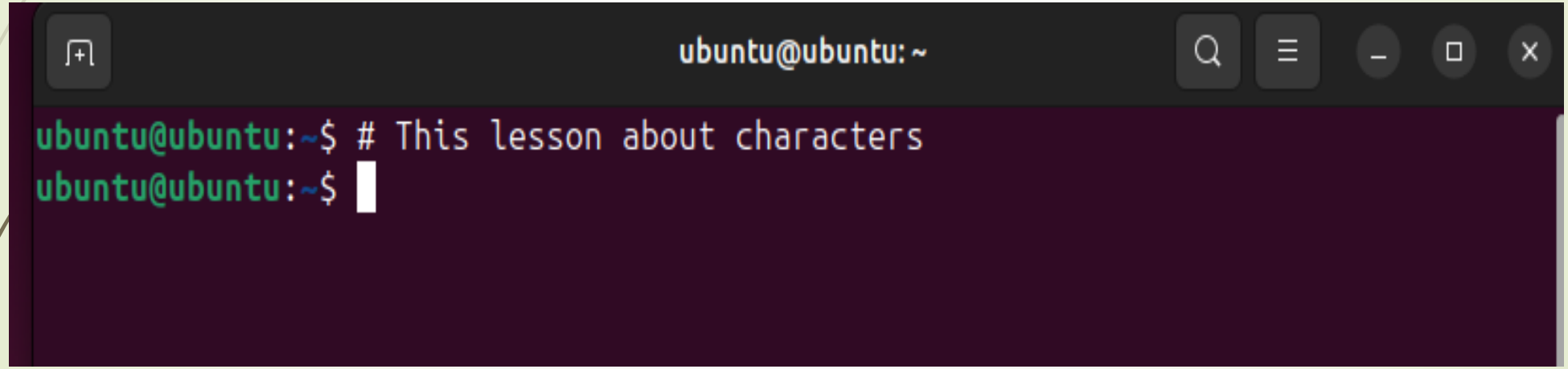
~ Home Directory or user's home directory.

- The tilde (~) is shorthand for your home directory. It means you don't have to type the full path to your home directory in commands. Wherever you are in the filesystem, you can use this command to go to your home directory:



Comment or Trim Strings

- Most often, you use the hash or number sign (#) to tell the shell what follows is a comment, and it should not act on it.



Administrative Access

- There are many Linux commands which deal with sensitive information like passwords, system hardware, or otherwise operate under other exceptional circumstances. Preventing regular users from executing these commands helps to protect the system. Logging in as the root user provides administrative access, allowing for the execution of some of the privileged commands.

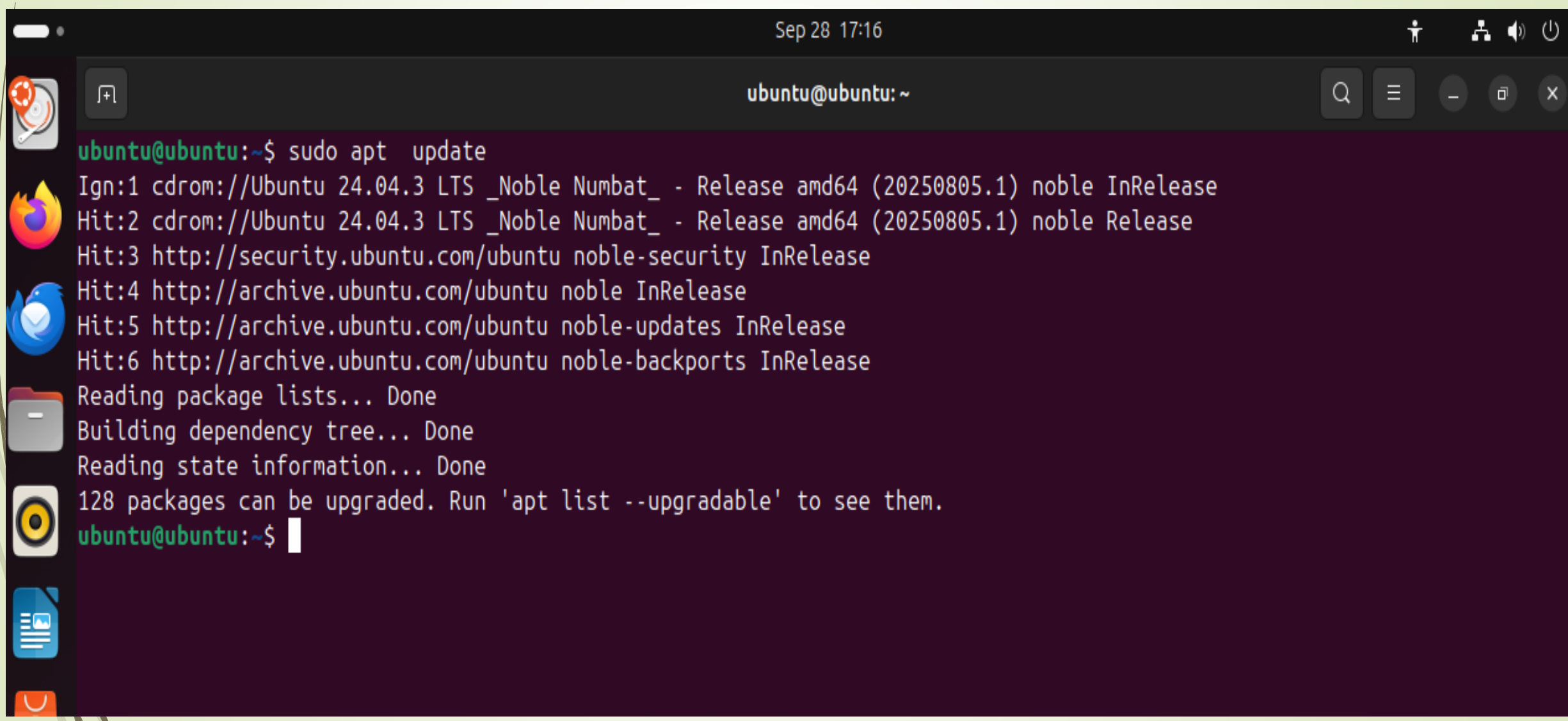
The root account

- In Linux, the **root account** is the most powerful user account. It has full administrative privileges and unrestricted access to all commands, files, directories, and system resources.
- Here's what you should know:
  - Root is the **superuser** in Linux.
  - Can install, remove, and update software.
  - Can manage user accounts and permissions.
  - Has access to system configuration files.
  - Can start/stop services and processes.
  - Can access or modify any file, even those belonging to other users.
  - root(Linux) = administrator (windows)

Sudo command

- sudo (**S**uper **U**ser **DO**) command in Linux is generally used as a prefix for some commands that only superusers are allowed to run. If you prefix any command with "sudo", it will run that command with elevated privileges or in other words allow a user with proper permissions to execute a command as another user, such as the superuser. This is the equivalent of the "run as administrator" option in Windows. The option of sudo lets us have multiple administrators.
- The sudo command allows a user to execute a command as another user without creating a new shell. Instead, to execute a command with administrative privileges, use it as an argument to the sudo command.

To update the system using sudo command



- Once the command has completed, notice the prompt has not changed, you are still logged in as sysadmin. The sudo command only provides administrative access for the execution of the specified command.
- This is an advantage as it reduces the risk that a user accidentally executes a command as root. The intention to execute a command is clear; the command is executed as root if prefixed with the sudo command. Otherwise, the command is executed as a regular user.

To enter the system as a root

```
ubuntu@ubuntu:~$ sudo
usage: sudo -h | -K | -k | -V
usage: sudo -v [-ABkNnS] [-g group] [-h host] [-p prompt] [-u user]
usage: sudo -l [-ABkNnS] [-g group] [-h host] [-p prompt] [-U user]
            [-u user] [command [arg ...]]
usage: sudo [-ABbEHkNnPS] [-r role] [-t type] [-C num] [-D directory]
            [-g group] [-h host] [-p prompt] [-R directory] [-T timeout]
            [-u user] [VAR=value] [-i | -s] [command [arg ...]]
usage: sudo -e [-ABkNnS] [-r role] [-t type] [-C num] [-D directory]
            [-g group] [-h host] [-p prompt] [-R directory] [-T timeout]
            [-u user] file ...
ubuntu@ubuntu:~$ sudo -i
root@ubuntu:~# exit
logout
ubuntu@ubuntu:~$
```

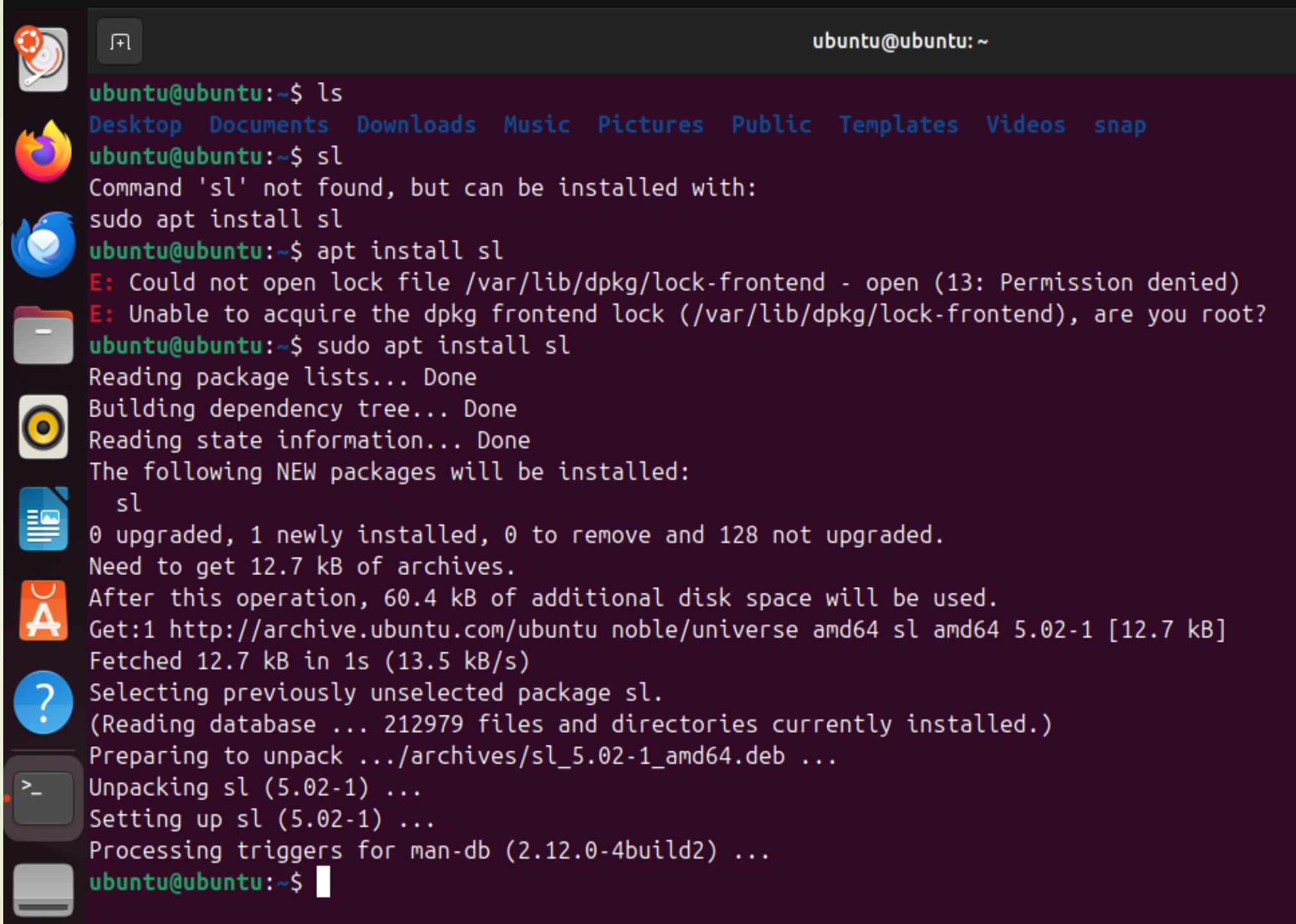
To update your system, you need to be a root

```
ubuntu@ubuntu:~$ sudo -i
root@ubuntu:~# apt update
Ign:1 cdrom://Ubuntu 24.04.3 LTS _Noble Numbat_ - Release amd64 (20250805.1) nob
le InRelease
Hit:2 cdrom://Ubuntu 24.04.3 LTS _Noble Numbat_ - Release amd64 (20250805.1) nob
le Release
Hit:3 http://archive.ubuntu.com/ubuntu noble InRelease
Get:4 http://security.ubuntu.com/ubuntu noble-security InRelease [126 kB]
Get:5 http://archive.ubuntu.com/ubuntu noble-updates InRelease [126 kB]
Get:6 http://archive.ubuntu.com/ubuntu noble-backports InRelease [126 kB]
Get:8 http://security.ubuntu.com/ubuntu noble-security/main amd64 Packages [1171
 kB]
Get:9 http://archive.ubuntu.com/ubuntu noble-updates/main amd64 Packages [1443 k
B]
Get:10 http://security.ubuntu.com/ubuntu noble-security/main i386 Packages [330
kB]
Get:11 http://security.ubuntu.com/ubuntu noble-security/main Translation-en [198
 kB]
Get:12 http://security.ubuntu.com/ubuntu noble-security/main amd64 Components [2
```

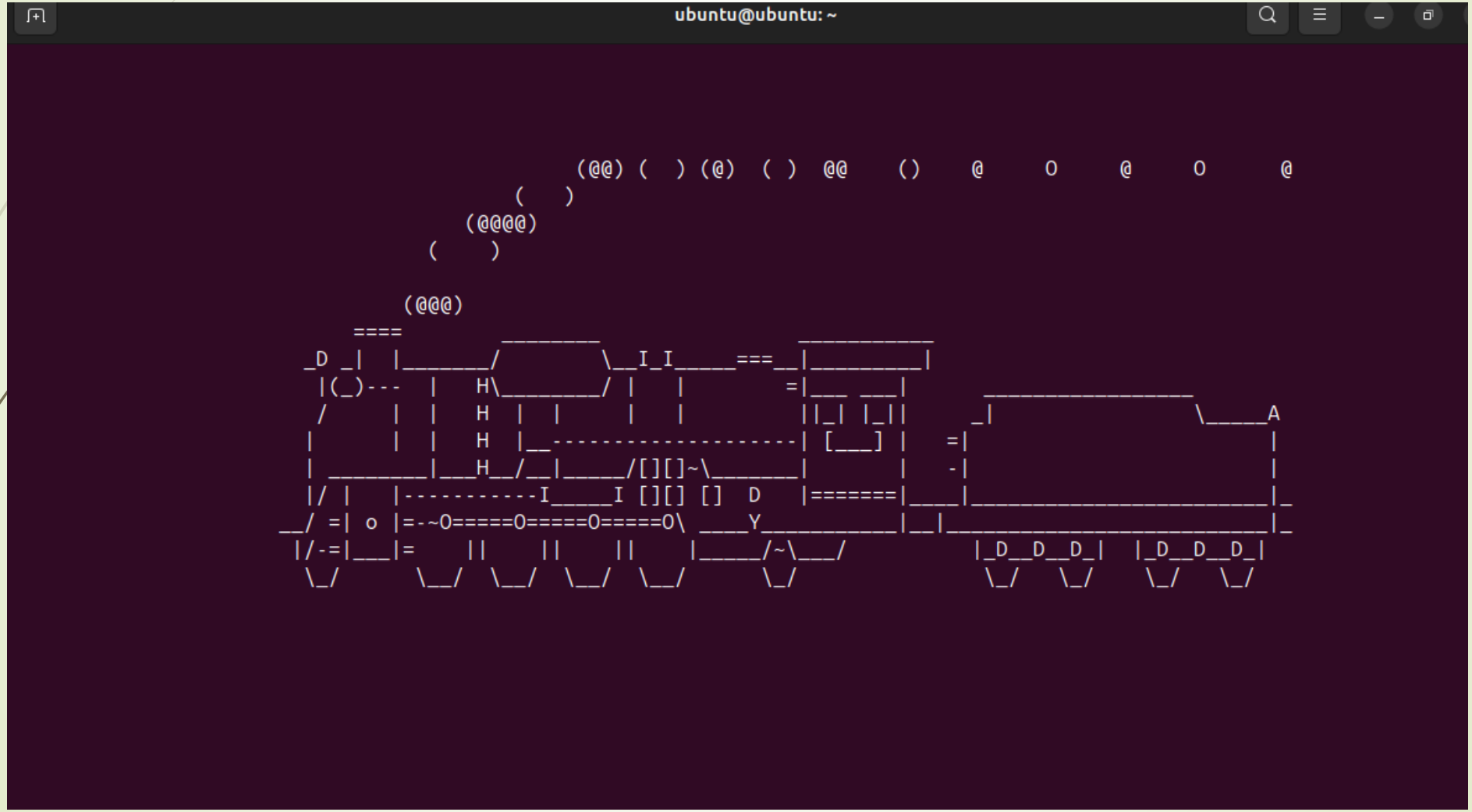
To logout the root user use exit command

```
ubuntu@ubuntu:~$ sudo -i
root@ubuntu:~# exit
logout
ubuntu@ubuntu:~$
```

sl command, to require administrative access.
If the command is executed as sysadmin, it fails



sl command run a train move on screen



References

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- Ramses van Zon," Securing File Access Permissions on Linux ", SciNet HPC, University of Toronto ,27 October 2022.
- https://www.geeksforgeeks.org/linux-unix/sudo-command-in-linux-with-examples/