

## Lecture 2. Symbolic and hard links. Permissions

root - the superuser

`/sys` is the virtual filesystem that displays some kernel configuration

```
# everything is a file so every kernel setting is also a file
```

```
regular files,  
directories,  
character devices (/dev/null)  
block devices (/dev/sda)
```

symbolic link

to create a symlink file use

```
ln -s file1.txt file6.txt
```

```
file6.txt container address to file1.txt
```

```
#symbolic link is qite simple and only store path to the linked file
```

[illegible]

```
bin is symbolic link to file usr/bin
```

```
lib -> usr/lib
```

```
lib64 -> usr/lib64
```

to read the symbolic link of a file we can use following statement

```
readlink file6.txt
```

```
output: /home/p/os/file6.txt
```

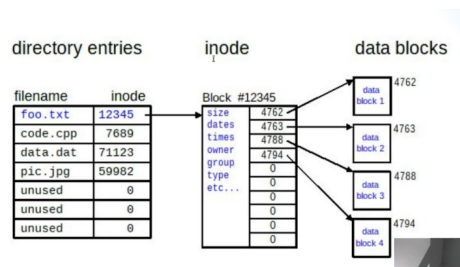
`$(pwd)` : store the dir to the cur path such as `$(pwd)/file1.txt`

## hardlink

```
filesystem = inodes + blocks
```

blocks store data

inodes file store metadata + pointer to data (but without filenames)



hardlink: contain make file point to the same inodes id

## file permission

stat file.txt

```
File: a.cpp
Size: 1440          Blocks: 8          IO Block: 4096   regular file
Device: 10302h/66306d Inode: 8388643    Links: 1
Access: (0664/-rw-rw-r--)  Uid: ( 1000/      p)   Gid: ( 1000/      p)
Access: 2025-03-17 07:16:09.667860730 +0700
Modify: 2025-03-17 07:16:09.647860595 +0700
Change: 2025-03-17 07:16:09.647860595 +0700
Birth: 2025-03-17 07:04:42.055239147 +0700
```

Access: specifies what kind of access we are allowed

Uid: specifies the owner of the file

Gid: specifies the owner group of the file. So if we see for example stat bin/bash

Uid: user = p, Gid = p

p@p:~/cpp\$ stat /bin/bash

```
File: /bin/bash
Size: 1396520      Blocks: 2728      IO Block: 4096   regular file
Device: 10302h/66306d Inode: 3145823    Links: 1
Access: (0755/-rwxr-xr-x) Uid: (   0/    root)  Gid: (   0/    root)
Access: 2025-03-17 16:22:36.508302034 +0700
Modify: 2024-03-14 18:31:47.000000000 +0700
Change: 2025-03-13 14:28:12.109753666 +0700
Birth: 2025-03-13 14:28:12.104755850 +0700
```

There are 3 types of permission: read, write, execute

the order of access following this: user/group/other

-rwxr-xr-x

- rwx: he can read write execute

  r-x: he can read and execute

  r-x: he can read and execute but not write the file

chmod, change file mode

chmod +x file.txt

then file will be added permission to execute

chmod -x file.txt

then file will be remove permission to execute

if we want to executable only for current user

user - u, group -g, other -o

chmod go-x file1.txt

+x will make your non-executable files executable - this is not what you want  
+X will just allow to view files and directorires

ma chmod

-r will remove rea permissions  
-R recursive

chown: change the owner of the file

chmod [user]:[group] [file]

sticky bit mean that only the file/directory owner can remove the file  
even you have write permisison

chmod -t

setgid

### Lecture 3. Setuid and Setgid Bits. Processes

setuid bit - changes euid to the owner of the file(instead of the user who invoked it)

can we change uid, the answer is yes? but it's only if we are root

why are all these setuid and setgid bits needed

escalate: to become or make something become greater or more serious

/'es.kə.leɪt/

sudo has owner root and setuid bit, invoke sode,  
-> euid is zero, sudo can call setuid() to change user

sudo checks permissions and asks for password if  
necessary

if success -> sudo just invokes your programs

setuid bit does work only on executabe programs and not on scripts

why?

./uids.py -> kernel read file metadata, check permissions, and executes/usr/bin/python3/uids.py

when /usr/bin/python3/ uids.py is executed, then python3 reads uids.py file again

suppose setuid works on sciprts, What happens?

- 1) we have setuid uids.py and invoke it
- 2) kernel reads our uids.py and invokes /usr/bin/python3 uids.py
- 3) kernel runs this program as setuid (as root)
- 4) we move uids.py (can do it if we have permissions on the directory) and replace it with our own contents
- 5) /usr/bin/python3 reads our uids.py (but now it's the wrong file)

thus we can execute any code as root

we dont often have write permissions on system directories  
hardlinks

when you write setuid programs, you have to be really extra careful

when writing setuid programs you also need to be careful what the libraries that you use do

when we execute the program -> **create a process**

has some computation resources (CPU, memory, etc)

then every process has exit code - integer show how the process exited

echo \$? # return last exit code

&& invokes the next command only if the previous one succeeds

|| i invokes the next commands only if the previous one failed

every process has its ID

ls /proc/

every process has command line

every process has its parent process id, its user, and group id (and effective user and group id)

ps: process status

pidof [name] : show the pid of process name

you can send signals to processes

signal numbers - just integers

man sign