CENTRO UNIVERSITARIO
DE TECNOLOGÍA Y ARTE DIGITAL

Software Engineer Degree Operating Systems, 2024-2025

PROYECT

This project is worth 30% of the final grade of the course. It is necessary to obtain a 4 to be able to release this subject.

In this practice we are going to develop a very simplified Linux *ext* file system simulator. Instead of working on a disk partition, we will use a binary file called *particion.bin* that contains the complete system.

The blocks of this particular system are 512 bytes in size, the partition occupies 100 blocks, and its layout is as described below. There is no boot block, as in an ext2 system, where block 0 is reserved for that purpose.

Block 0 of *partition.bin* is occupied by the superblock. In the *header.h* file provided with the statement, you will find its definition.

```
/* Estructura del superbloque */
typedef struct {
  unsigned int  s_inodes_count;          /* inodos de la partición */
  unsigned int  s_blocks_count;          /* bloques de la partición */
  unsigned int  s_free_blocks_count;     /* bloques libres */
  unsigned int  s_free_inodes_count;     /* inodos libres */
  unsigned int  s_first_data_block;      /* primer bloque de datos */
  unsigned int  s_block_size;            /* tamaño del bloque en bytes */
  unsigned char s_relleno[SIZE_BLOQUE-6*sizeof(unsigned int)]; /* relleno a
0's*/
} EXT_SIMPLE_SUPERBLOCK;
```

To simplify the problem, instead of bitmaps, we will use bytemaps or byte arrays for blocks and inodes. In the inode bytemap, if the byte M is 1, it means that the inode is occupied, if it is 0 it is free. The same for the block bytemap.

```
/* Bytemaps, caben en un bloque */
typedef struct {
  unsigned char bmap_bloques[MAX_BLOQUES_PARTICION];
```

```
  unsigned char bmap_inodos[MAX_INODOS];  /* inodos 0 y 1 reservados, inodo 2
directorio */
   unsigned char bmap_relleno[SIZE_BLOQUE-
(MAX_BLOQUES_PARTICION+MAX_INODOS)*sizeof(char)];
} EXT_BYTE_MAPS;
```

The block bytemap has 100 elements. The first 4 are occupied by the superblock, the bytemaps, the inode list and the directory. The remaining 96 are the data blocks. The inode bytemap has 24 elements. Inodes 0 and 1 are reserved but not used, and 2 corresponds to the directory.

In block 3 is the list of inodes. The simplified inode has the following structure:

```
/* inodo */
typedef struct {
  unsigned int size_fichero;
  unsigned short int i_nbloque[MAX_NUMS_BLOQUE_INODO];
} EXT_SIMPLE_INODE;
```

The inode stores the size in bytes of the file's payload, if it is not occupied the value of that field is 0. In addition there is a list of up to 7 data block numbers where the payload is located. If a file occupies blocks 5, 11 and 7, the elements 0, 1 and 2 of the array *i_nblock* take those values and the rest are worth FFFFH. To retrieve the contents, blocks 5, 11 and 7 must be concatenated in that order. The inode list has 24 elements.

In block 3 is the directory. This system can store up to 20 files. For each file there is an entry containing the file name and the inode number. The entry 0 of the directory, contains the name '.' and the inode number 2. The rest are empty, and for them the inode value is FFFFH.

```
typedef struct {
  char dir_nfich[LEN_NFICH];
  unsigned short int dir_inodo;
} EXT_ENTRADA_DIR;
```

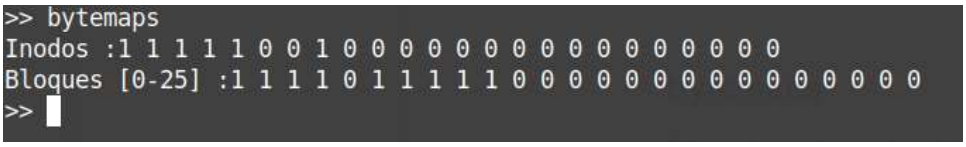
You are asked to develop a C program, called *simul_ext.c*, that reads the contents of the binary file *partition.bin* into an array of bytes in memory and enters an infinite loop of command processing. The program will display a prompt of the form >> to the user and will be able to handle the commands specified below (in order from least to most complicated).

info

This command displays the superblock information on the screen.

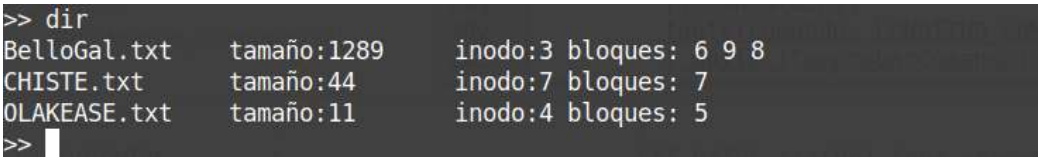
bytemaps.

It displays the content of the inode bytemap and the first 25 elements of the block bytemap. This command will be very useful during development.



dir

Lists all files (except the special root directory entry). For each one it will show its name, size, inode and blocks it occupies. The names are case sensitive.



rename

Renames a file in the corresponding entry, but does not modify nodes or lists. The command must check that the source file exists and that the new name does not exist, otherwise it will give an error.

```
>> dir
BelloGal.txt    tamaño:1289     inodo:3 bloques: 6 9 8
CHISTE.txt      tamaño:44       inodo:7 bloques: 7
OLAKEASE.txt    tamaño:11       inodo:4 bloques: 5
>> rename HOLA.txt ADIOS.txt
ERROR: Fichero HOLA.txt no encontrado
>> rename OLAKEASE.txt CHISTE.txt
ERROR: El fichero CHISTE.txt ya existe
>> rename OLAKEASE.txt HOLA.txt
>> dir
BelloGal.txt    tamaño:1289     inodo:3 bloques: 6 9 8
CHISTE.txt      tamaño:44       inodo:7 bloques: 7
HOLA.txt        tamaño:11       inodo:4 bloques: 5
>>
```

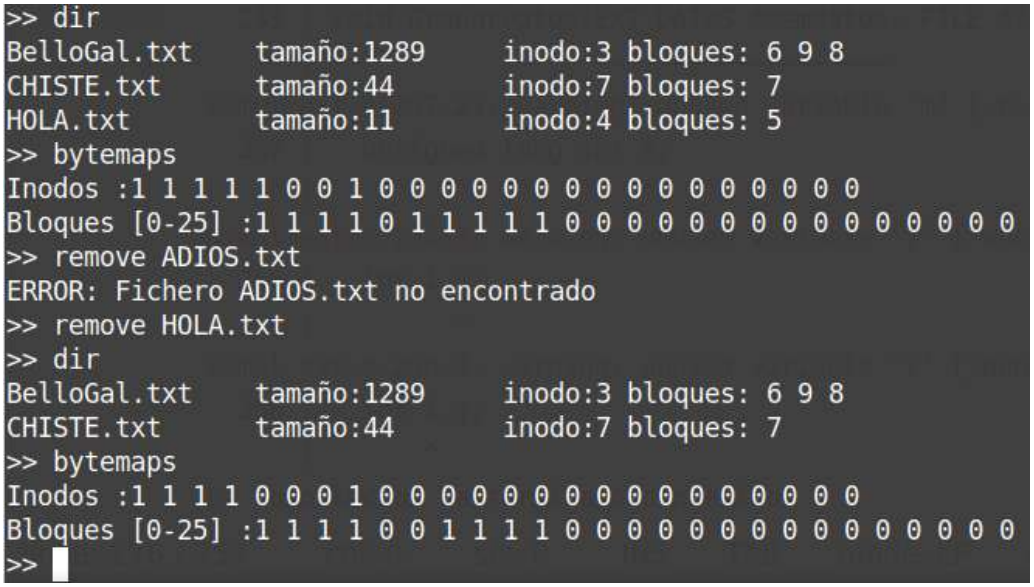
Imprimir/print

Displays the contents of the specified file as text. You must check that the file exists. If the file occupies more than one block, it must appear in the correct order.

```
>> imprimir PEPE.txt
ERROR: Fichero PEPE.txt no encontrado
>> imprimir HOLA.txt
OLA KE ASE?
>> imprimir BelloGal.txt
Gallia est omnis divisa in partes tres, quarum unam incolunt Belgae,
aliam Aquitani, tertiam qui ipsorum lingua Celtae, nostra Galli appellantur.
Hi omnes lingua, institutis, legibus inter se differunt.
Gallos ab Aquitanis Garumna flumen, a Belgis Matrona et Sequana dividit.
Horum omnium fortissimi sunt Belgae, propterea quod a cultu atque humanitate
provinciae longissime absunt, minimeque ad eos mercatores saepe commeant
atque ea quae ad effeminandos animos pertinent important, proximique sunt
Germanis, qui trans Rhenum incolunt, quibuscum continenter bellum gerunt.
Qua de causa Helvetii quoque reliquos Gallos virtute praecedunt,
quod fere cotidianis proeliis cum Germanis contendunt, cum aut suis
finibus eos prohibent aut ipsi in eorum finibus bellum gerunt.
Eorum una pars, quam Gallos obtinere dictum est, initium capit a flumine
Rhodano, continetur Garumna flumine, Oceano, finibus Belgarum, attingit
etiam ab Sequanis et Helvetiis flumen Rhenum, vergit ad septentriones.
Belgae ab extremis Galliae finibus oriuntur, pertinent ad inferiorem
partem fluminis Rheni, spectant in septentrionem et orientem solem.
Aquitania a Garumna flumine ad Pyrenaeos montes et eam partem Oceani
quae est ad Hispaniam pertinet; spectat inter occasum solis et
septentriones.
```

remove

Delete the file. The program must mark the inode and the free blocks in the bytemaps, put size 0 in the freed inode, mark the 7 block pointers of that inode with the value FFFFH and delete the directory entry, putting an empty string in the name and the value FFFFH in the inode number. It is not necessary to delete the physical content of the information blocks.



copy

Copy a file. You must check that the source file exists and that the destination file exists. For simplicity, you do not have to check that the maximum number of files in the partition is exceeded. You have to find the first free inode, assign it to the new file, copy the size and mark the inode as busy. Then loop over the list of block numbers in the source file. The first free block in the block bytemap is searched for, that number is assigned in the block list of the target inode and the data content of the block is copied to the first free block, which is marked as busy in the block bytemap.

In addition, an entry will be created in the first available vacancy in the directory with the file name and its inode number.

```
>> dir
BelloGal.txt    tamaño:1289     inodo:3 bloques: 6 9 8
CHISTE.txt      tamaño:44       inodo:7 bloques: 7
>> Copy BelloGal.txt Cesar.txt
>> dir
BelloGal.txt    tamaño:1289     inodo:3 bloques: 6 9 8
Cesar.txt       tamaño:1289     inodo:4 bloques: 4 5 10
CHISTE.txt      tamaño:44       inodo:7 bloques: 7
>> bytemaps
Inodos :1 1 1 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Bloques [0-25] :1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
>> imprimir Cesar.txt
Gallia est omnis divisa in partes tres, quarum unam incolunt Belgae,
aliam Aquitani, tertiam qui ipsorum lingua Celtae, nostra Galli appellantur.
Hi omnes lingua, institutis, legibus inter se differunt.
Gallos ab Aquitanis Garumna flumen, a Belgis Matrona et Sequana dividit.
Horum omnium fortissimi sunt Belgae, propterea quod a cultu atque humanitate
provinciae longissime absunt, minimeque ad eos mercatores saepe commeant
atque ea quae ad effeminandos animos pertinent important, proximique sunt
Germanis, qui trans Rhenum incolunt, quibuscum continenter bellum gerunt.
Qua de causa Helvetii quoque reliquos Gallos virtute praecedunt,
quod fere cotidianis proeliis cum Germanis contendunt, cum aut suis
finibus eos prohibent aut ipsi in eorum finibus bellum gerunt.
Eorum una pars, quam Gallos obtinere dictum est, initium capit a flumine
Rhodano, continetur Garumna flumine, Oceano, finibus Belgarum, attingit
etiam ab Sequanis et Helvetiis flumen Rhenum, vergit ad septentriones.
Belgae ab extremis Galliae finibus oriuntur, pertinent ad inferiorem
partem fluminis Rheni, spectant in septentrionem et orientem solem.
Aquitania a Garumna flumine ad Pyrenaeos montes et eam partem Oceani
quae est ad Hispaniam pertinet; spectat inter occasum solis et
septentriones.
```

In this example we have copied the file Cesar.txt re introduction of "De Bello Gallico" to the file Cesar.txt. The original occupies blocks 6, 9 and 8 and the copy occupies blocks 4, 5 and 10. The original is described in inode 3 and the copy in inode 4.

exit

This simple command terminates the session.

Unknown command

If the user requests an unknown command, you should see this error message.

```
>> date
ERROR: Comando ilegal [bytemaps,copy,dir,info,imprimir,rename,remove,salir]
```

HELP & HINTS

The student has the file *headers.h* and a skeleton of what must be developed. The teacher can also give some visual aids to facilitate the understanding of the practice.

Practice Deliverable

The practice will be developed in teams of two people. Only one member of each team is required to deliver.

You have to deliver in two places:

1. GitHub

- One member will be the owner of the github repository, and has to invite the other member as a contributor. The repository has to be public so that the teacher can see it or you will have to invite the teacher to the account he/she gives you if you want to keep it private.

- There must be commits from both members and also commits with their comment.

- You must upload a README.txt file with the names of the students.

- The source simul_ext.c

- A file with the link to an explanatory video of no more than 10 minutes in which both members will speak, explaining the execution of the program. The video will be hosted in one drive, youtube, Dropbox, etc.

2. Blackboard

- This is a backup in case the Github does not work. If that is the case there will be a penalty in the grade.

- Upload the simul_ext.c source.

- You must submit a pdf file (2 sheets maximum) containing:

o the names of the students.

o a link to an explanatory video

o A table in which for each of the evaluation points below it is indicated if it is done or not and a comment column where difficulties encountered are indicated, how they were solved and if it was not done what was the cause. Example:

Element	Done Yes/no	Comment
Start		
Exit and error messages		
info		
bytemaps		
dir		
rename		
Remove (say if it Works with files of 1 block		

only or with several blocks)		
Print (say if it Works with files of 1 block only or with several blocks)		
(say if it Works with files of 1 block only or with several blocks)		
Commits, documentation and video		

Evaluation

- The program starts correctly, reads the partition.bin file and initializes the variables with proper error checking. Loop of request and command reading loop (1 point)
- exit command and error message if command does not exist (0.5 points)
- info command (0.5 points).
- bytemaps command (0.5 points).
- dir command (0,5 points).
- rename command (0.5 points).
- remove command (1 point if it works for 1 block files, 1.5 points for multiblock).
- print command (1 point if it works for 1-block files, 1.5 points for multiblock).
- copy command (1 point if it works for 1-block files, 2.5 points for multi-block)
- Commits are properly documented, the code is well documented and structured (1 point). The video is part of the documentation.