



KFS_6

Filesystem

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Summary: Disk, files and format!

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Chapter I

Foreword

I don't have any idea for this foreword. So here's a penguin:



A good one.

Chapter II

Introduction

Filesystem! Finally, some files in our kernel. We have two things to discuss:

II.0.1 Filesystem

Let's see the wikipedia definition, but I'm sure you all know what a filesystem is by now:

In computing, a file system (or filesystem) is used to control how data is stored and retrieved. Without a file system, information placed in a storage area would be one large body of data with no way to tell where one piece of information stops and the next begins. By separating the data into pieces and giving each piece a name, the information is easily isolated and identified. Taking its name from the way paper-based information systems are named, each group of data is called a "file". The structure and logic rules used to manage the groups of information and their names is called a "file system".

Nothing to add here, I'm sure you're all comfortable with the concept of files.

II.0.2 Ext2

Ext2 is a type of filesystem known to be really light and easy to implement. You already know it, but here's the definition:

The ext2 or second extended filesystem is a file system for the Linux kernel. It was initially designed by Rémy Card as a replacement for the extended file system (ext). Having been designed according to the same principles as the Berkeley Fast File System from BSD, it was the first commercial-grade filesystem for Linux. The canonical implementation of ext2 is the "ext2fs" filesystem driver in the Linux kernel. Other implementations (of varying quality and completeness) exist in GNU Hurd, MINIX 3, some BSD kernels, in MiNT, and as third-party Microsoft Windows and OS X drivers. ext2 was the default filesystem in several Linux distributions, including Debian and Red Hat Linux, until supplanted more recently by ext3, which is almost completely compatible with ext2 and is a journaling file system. ext2 is still the filesystem of choice for flash-based storage media (such as SD cards, and USB flash drives), since its lack of a journal increases performance and minimizes the number of writes, and flash devices have a limited number of write cycles. However, recent Linux kernels support a journal-less mode of ext4 which provides benefits not found with ext2.

II.0.3 IDE

Now that's something you don't know anything about. Don't worry:

Parallel ATA (PATA), originally AT Attachment, is an interface standard for the connection of storage devices such as hard disk drives, floppy disk drives, and optical disc drives in computers. The standard is maintained by the X3/INCITS committee. It uses the underlying AT Attachment (ATA) and AT Attachment Packet Interface (ATAPI) standards. The Parallel ATA standard is the result of a long history of incremental technical development, which began with the original AT Attachment interface, developed for use in early PC AT equipment. The ATA interface itself evolved in several stages from Western Digital's original Integrated Drive Electronics (IDE) interface. As a result, many near-synonyms for ATA/ATAPI and its previous incarnations are still in common informal use, in particular Extended IDE (EIDE) and Ultra ATA (UATA). After the introduction of Serial ATA (SATA) in 2003, the original ATA was renamed to Parallel ATA, or PATA for short. The term Integrated Drive Electronics refers not just to the connector and interface definition, but also to the fact that the drive controller is integrated into the drive, as opposed to a separate controller on or connected to the motherboard. The interface cards used to connect a parallel ATA drive to, for example, a PCI slot are not drive controllers: they are merely bridges between the host bus and the ATA interface. Since the original ATA interface is essentially just a 16-bit ISA bus in disguise, the bridge was especially simple in case of an ATA connector being located on an ISA interface card. The integrated controller presented the drive to the host computer as an array of 512-byte blocks with a relatively simple command interface. This relieved the mainboard and interface cards in the host computer of the chores of stepping the disk head arm, moving the head arm in and out, and so on, as had to be done with earlier ST-506 and ESDI hard drives. All of these low-level details of the mechanical operation of the drive were now handled by the controller on the drive itself. This also eliminated the need to design a single controller that could handle many different types of drives, since the controller could be unique for the drive. The host need only ask for a particular sector, or block, to be read or written, and either accept the data from the drive or send the data to it.

Lots of complicated words, but don't panic, just remember that an IDE is an interface for disk writing, with basic standards. It's one of the simplest interfaces out there, easy to implement. Let's talk about it in more detail.

II.0.4 IDE Controller

If you open your case up and take a look at your motherboard, you will most likely see one or two (or possibly more) slots for an IDE controller.

The white and green ports are IDE ports, also known as channels. In this example there are both primary and secondary IDE channels which only PATA can be connected to; this means that it only supports PATA/PATAPI drives.

Each port can have a PATA cable connected to it. One master drive or two drives (master and slave) can be connected to one PATA cable. So that leaves us with the following possibilities:

- Primary Master Drive.
- Primary Slave Drive.
- Secondary Master Drive.
- Secondary Slave Drive.

Each drive can be either PATA or PATAPI. Each IDE controller appears as a device on the PCI bus. If the class code is 0x01 (Mass Storage Controller) and the subclass code is 0x1, (IDE) this device is an IDE Device. The IDE device only uses five BARs out of the six ones.

- BAR0: Base address of primary channel (I/O space), if it is 0x0 or 0x1, the port is 0x1F0.
- BAR1: Base address of primary channel control port (I/O space), if it is 0x0 or 0x1, the port is 0x3F6.
- BAR2: Base address of secondary channel (I/O space), if it is 0x0 or 0x1, the port is 0x170.
- BAR3: Base address of secondary channel control port, if it is 0x0 or 0x1, the port is 0x376.
- BAR4: Bus Master IDE; refers to the base of I/O range consisting of 16 ports. All 8 ports control DMA on the primary and secondary channel respectively.

Chapter III

Goals

At the end of this project, you will add the following to your kernel:

- A complete interface to read / write an IDE.
- A complete interface to read / write / delete an `ext2` filesystem.
- A basic file tree (`/sys`, `/var`, `/dev`, `/proc`, `/sys`).

Chapter IV

General instructions

IV.1 Code and Execution

IV.1.1 Emulation

The following part is not mandatory, you're free to use any virtual manager you want; however, I suggest you use KVM. It's a **Kernel Virtual Manager** with advanced execution and debug functions. All of the examples below will use KVM.

IV.1.2 Language

The C language is not mandatory, you can use any language you want for this series of projects.

Keep in mind that not all languages are kernel friendly, you could code a kernel in **Javascript**, but are you sure it's a good idea?

Also, most of the documentation is written in C, you will have to 'translate' the code all along if you choose a different language.

Furthermore, not all the features of a given language can be used in a basic kernel. Let's take an example with **C++**:

this language uses 'new' to make allocations, classes and structures declarations. But in your kernel you don't have a memory interface (yet), so you can't use any of these features.

Many languages can be used instead of C, like **C++**, **Rust**, **Go**, etc. You can even code your entire kernel in **ASM**!



IV.2 Compilation

IV.2.1 Compilers

You can choose any compiler you want. I personally use `gcc` and `nasm`. A Makefile must be turned-in as well.

IV.2.2 Flags

In order to boot your kernel without any dependency, you must compile your code with the following flags (adapt the flags for your language, these are `C++` examples):

- `-fno-builtin`
- `-fno-exception`
- `-fno-stack-protector`
- `-fno-rtti`
- `-nostdlib`
- `-nodefaultlibs`

You might have noticed these two flags: `-nodefaultlibs` and `-nostdlib`. Your Kernel will be compiled on a host system, that's true, but it cannot be linked to any existing library on that host, otherwise it will not be executed.

IV.3 Linking

You cannot use an existing linker in order to link your kernel. As mentionned above, your kernel would not be initialized. So you must create a linker for your kernel. Be carefull, you **CAN** use the `'ld'` binary available on your host, but you **CANNOT** use the `.ld` file of your host.

IV.4 Architecture

The i386 (x86) architecture is mandatory (you can thank me later).

IV.5 Documentation

There is a lot of documentation available, good and bad. I personally think the [OSDev](#) wiki is one of the best.

IV.6 Base code

In this subject, you have to take your previous `KFS` code, and work from it! Or don't. And rewrite everything from scratch. Your call!

Chapter V

Mandatory part

For this subject, you will have to implement a complete and functional filesystem interface. Let's see that, point by point:

- Write a complete interface to read / write an IDE.
- Write a complete interface to read an ext2 filesystem:
 - Read the ext2 headers.
 - Create and fill in an ext2 kernel-side structure with groups, super blocks, blocks and inodes.
- Write a complete structure for a filesystem. That includes:
 - Name
 - Size
 - Type
 - Inode
 - Links
 - Master
 - Father
 - Children
 - Rights
 - Next of kin

You will have to implement a `cat` command in your console, with the behavior of the original `cat`. Now that you have a root directory, you need to code a directory change too (`pwd` / `cd`) in your console. Keep in mind that a process needs to have its own `pwd`, and two processes can have different `pwd`s at the same time.

Chapter VI

Bonus part

For the bonuses, you will have to handle multiple partitions, mount and demount.
You can, also, implement users (with passwords, logins, etc.).

Chapter VII

Turn-in and peer-evaluation

Turn your work in using your `Git` repository, as usual. Only the work present on your repository will be graded in the evaluation.

Your must turn in your code, a `Makefile` and a basic virtual image for your kernel. Side note about that image, THERE IS NO NEED TO BE BUILT LIKE AN ELEPHANT.