

Informatics 1

Operating systems

Ferenc Wettl
Kristóf Kovács

Budapest University of Technology and Economics

2018-10-01

BIOS (Basic Input/Output System)

- What comes before the operating system? How does a computer know from where to load the operating system? How does a computer without an operating system know how to use a monitor or a keyboard?
- The first thing that comes online once a computer starts is the **BIOS**.
- This is a minimal system integrated into the **motherboard**, its main task is to initialize the computer.
- There are **drivers** stored inside the BIOS for the use of basic input / output devices
 - drivers are software that describes to the machine how a component works
- The BIOS finds the highest priority HDD and starts to load the operating system.

BIOS (Basic Input/Output System)

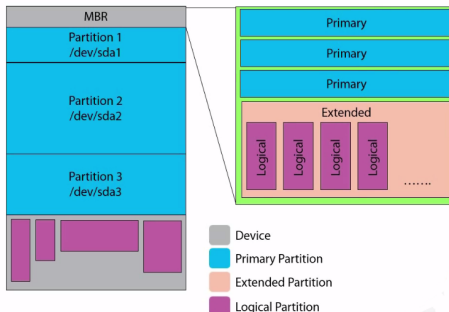


MBR (Master Boot Record)

- The first step in loading the operating system is when the BIOS reads the first 512 bytes of the chosen HDD, this is called the **MBR**.
- The first part of the MBR is a short code (**bootstrap** code), which describes the steps of starting the operating system.
- The next part is the **partition table**
- The third and last part of the MBR is the **magical number**, which is the same for all computers (**0xAA55** = **0b1010101001010101**, this is a failsafe, a way to check if the MBR is valid.
- Until this point the starting procedure of the machine is independent of the operating system.

- After the MBR there can be one or more partitions
- There can be at most 4 **primary partitions**.
- It is recommended to install your operating system on a primary partition (Windows can only be installed there).

MBR Partition Scheme



Extended partition

- The extended partition counts as a primary partition, so there can be at most 3 primary and 1 extended partition on a storage device.
- It can contain however many **logical partition** this is a possible way to have more than 4 partitions.
- It can only be located at the end of the storage device, no primary partition can follow it.
- Windows usually creates a **recovery partition** on install, which comes before the partition of the operating system, should the operating system fail, it will try to recover itself using this partition.
- Linux uses multiple partitions (usually 4), one of them is the previously mentioned **virtual memory**. This is where the unused part of the memory can be stored (swapping, paging).

Example for a graphical partition manager

The screenshot shows the GParted application window titled "/dev/sdb - GParted". The interface includes a menu bar (GParted, Edit, View, Device, Partition, Help), a toolbar with icons for creating, deleting, moving, and copying partitions, and a dropdown menu showing the selected device as "/dev/sdb (465.76 GiB)".

At the top, a visual representation of the disk layout is shown. It includes a yellow partition labeled "/dev/sdb7 47.49 GiB", a large yellow partition labeled "/dev/sdb8 293.65 GiB", and a green partition labeled "/dev/sdb6 68.35 GiB".

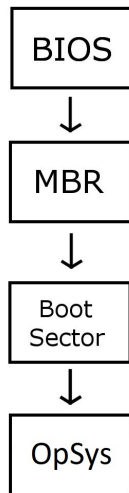
Below the visual layout is a table listing the partitions with their details:

Partition	File System	Mount Point	Label	Size	Used	Unused	Flags
/dev/sdb1	ext4	/		18.86 GiB	3.04 GiB	15.82 GiB	boot
▼ /dev/sdb2	extended			446.90 GiB	---	---	
/dev/sdb7	ntfs		Back Up Data	47.49 GiB	---	---	
/dev/sdb8	ext4	/media/Big_L	Big L	293.65 GiB	124.88 GiB	168.77 GiB	
/dev/sdb9	ntfs	/media/Documents	Documents	34.18 GiB	5.10 GiB	29.08 GiB	
/dev/sdb6	ext4	/home		68.35 GiB	1.57 GiB	66.79 GiB	
/dev/sdb5	linux-swap			3.22 GiB	---	---	

At the bottom of the window, a status bar indicates "0 operations pending".

Boot Sector

- At the beginning of every primary partition is a **Boot Sector**, the MBR stores the location of this sector and this is what starts to load the operating system.
- Similarly to the MBR this is a 512 byte sector as well, which provides the necessary instructions to start the operating system, this stores a magical number as well.
- On linux systems the Boot Sector is actually empty and the operating system is loaded in another way, this is why it is possible to install linux onto a logical partition.
- If the machine's storage device contains more than one operating system and the MBR contains the necessary instructions, then it is possible to choose which one to load at every start.



File system

A protocol how the files are stored on a partition.

Operating system	WINDOWS	LINUX	MAC	Mobile storage
File system	NTFS	ext4	HFS+	FAT32 or NTFS

- FAT32 is an older format
- it is used mostly for compatibility reasons

Files of the operating system

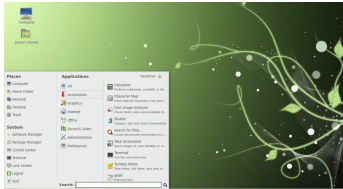
- Operating system (OS): core program, which
 - directly controls the hardware (memory, peripherals,...),
 - provides a unified environment for applications,
 - organizes the execution of these applications,
 - handles possible program failures,
 - handles files,
 - provides basic protection to the machine,
 - logs important operation events. . .
- The OS is part of the **system programs**
- Another system programs for example are anti-viruses, file compressors, file encrypters, file explorers, network programs, task manager...

Types of operating systems

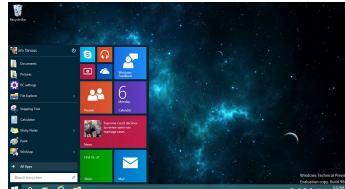
- single-, multi-user
- single-, multi-tasking
- distributed (cloud),
- embedded (for small machines, with limited resources)
- by its role: personal, server, . . .
- by the step of memory addressing 32- or 64 bits (processors themselves use 32 or 64 bits, in essence they either use numbers stored on 32 bits or 64 bits)

Two important part of operating systems

- **Kernel:** provides basic control over the hardware, organizes the resources required by the running programs.
- **Shell:** the user interface to the system. It can be graphical or command bases.



```
glider@debian:~$ echo $SHELL
/bin/bash
glider@debian:~$ echo $HOME
/home/glider
glider@debian:~$ whoami
glider
glider@debian:~$ hostname
debian
glider@debian:~$ echo $USER
glider
glider@debian:~$ echo $HOSTNAME
debian
glider@debian:~$ date
Sat Sep 1 16:40:52 BST 2007
glider@debian:~$ uname -a
Linux debian 2.6.18-5-686 #1 SMP Fri Jun 1 00:47:00 UTC 2007 i686 GNU/Linux
glider@debian:~$ uptime
16:50:03 up 28 min, 2 users, load average: 0.00, 0.01, 0.05
glider@debian:~$ clear
```



```
C:\WINDOWS\system32\cmd.exe

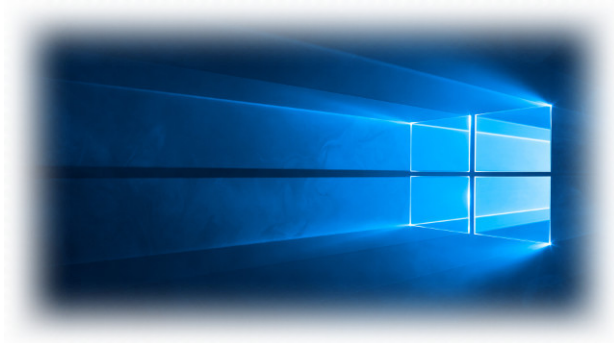
C:\test>dir
C:\test
C:\test
C:\test>dir
C:\test\dir
Volume in drive C has no label:
Volume Serial Number is 1643-0C37

Directory of C:\test

07/18/2004  08:06 PM    <DIR>        .
07/18/2004  08:06 PM    <DIR>        ..
07/18/2004  08:06 PM             4,096 bytes  a.txt
07/18/2004  08:07 PM             27 bytes    b.txt
07/18/2004  08:07 PM             1,824 bytes  c.txt
07/18/2004  08:10 PM             64,128 bytes d.txt
07/18/2004  08:10 PM             72,875 bytes e.txt
07/18/2004  08:10 PM             11,792,121,956 bytes free

C:\test>dir \
C:\test>
```

Windows summary



- File system: NTFS
- Source code: closed
- Used on most PCs
- Developed in batches, there is always an actively developed branch (Windows 10), while the older versions only get smaller fixes and security updates (Windows 7, 8.1), or nothing at all (Windows XP)

Linux summary



- File system: ext4
- Source code: open
- Most widespread on servers, but also used on personal computers
- Development is on multiple branches, there are a number of different distributions, there are branches specialized for research or programming (SUSE) and there are those for simple users (Linux Mint, Ubuntu).

Android summary



Cupcake
Android 1.5



Donut
Android 1.6



Eclair
Android 2.0/2.1



Froyo
Android 2.2.x



Gingerbread
Android 2.3.x



Honeycomb
Android 3.x



Ice Cream Sandwich
Android 4.0.x



Jelly Bean
Android 4.1.x



KitKat
Android 4.4.x



Lollipop
Android 5.0



Marshmallow
android 6.0



Nougat
android 7.0

- File system: varies, optimized for flash memory: yaffs2, vfat (SD-card), (Samsung: Flash-Friendly File System f2fs),...
- Source code: open
- Mostly used on mobile phones, tablets, smart watches, TVs, cars,...