Booting Linux

Jack Rosenthal
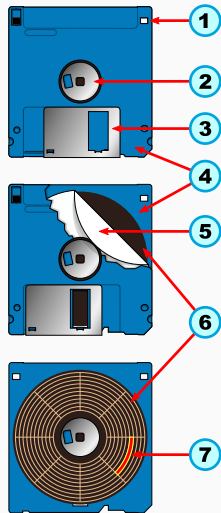February 23, 2017

Mines Linux Users Group

Master Boot Record
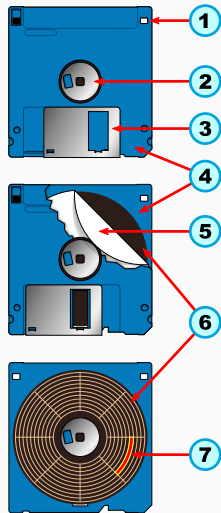
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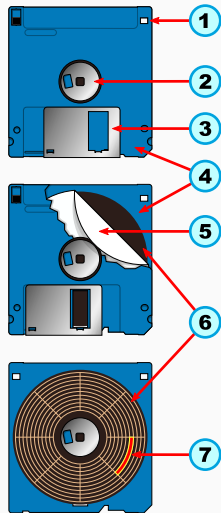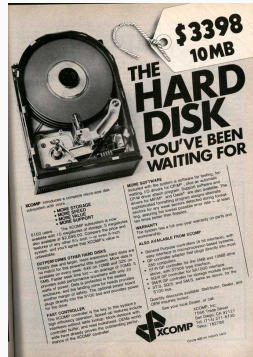
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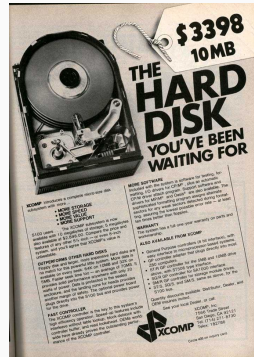- This is called Master Boot Record

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Master Boot Record

Address		Description		Size (bytes)
Hex	**Dec**			
+000$_{hex}$	+0	Bootstrap code area		446
+1BE$_{hex}$	+446	Partition entry №1		16
+1CE$_{hex}$	+462	Partition entry №2	Partition table (for primary partitions)	16
+1DE$_{hex}$	+478	Partition entry №3		16
+1EE$_{hex}$	+494	Partition entry №4		16
+1FE$_{hex}$	+510	55$_{hex}$	*Boot signature*[a]	2
+1FF$_{hex}$	+511	AA$_{hex}$		
			Total size: 446 + 4×16 + 2	**512**

1. Determine the partition to boot from
2. Determine where your kernel image is on the partition
3. Load the kernel into memory
4. Enable protected mode
5. Set up the environment for the kernel (stack space, etc.)
6. Call your kernel's `main` function

You will probably agree, that's a lot to do in 446 bytes of machine code.

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Some *Real* Challenges

- Most C compilers won't compile to real mode code, so booting is on the *list of things you can't even do in C*

- Real mode uses 16 memory segments of 64K each

- To switch segments, you must issue special instructions to the processor

- This gives you a total of 1 MiB of memory to use for booting

- Does your kernel fit in 1 MiB? Minus the memory you are using for your program to boot?

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Approaches to Solving Booting Challenges

- **Geek Booting:** Do everything your kernel needs to boot in the 512-byte boot sector. You will need your kernel to fit in 1 MiB as well. This is hard.

- **One-Stage Booting:** Write your bootloader in the first 1 MiB of your kernel image, then write a 512-byte program that loads that program. The 1 MiB program is responsible for loading the rest of your kernel and booting it.

- **Two-Stage Booting:** Write a separate kernel that fits in 1 MiB called a bootloader. This program is responsible for providing a high level interface to boot other kernels. GRUB is an example.

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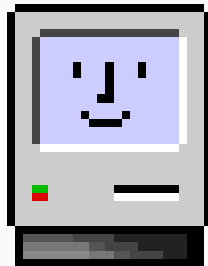
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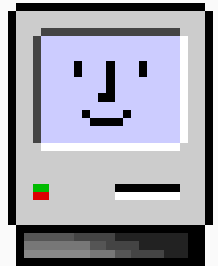
Extensible Firmware Interface

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- The Mac ROM provided a miniature operating system (with a mouse cursor and all) capable of booting Mac OS

- With the switch to PowerPC from 68K, Apple modified the ROM to include an Open Firmware Interface capable of extending booting capabilities beyond just classical Mac OS
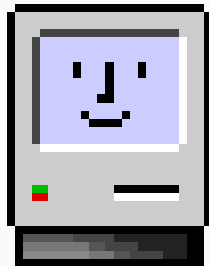
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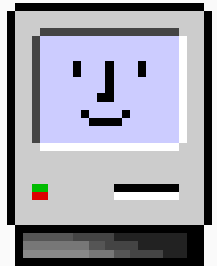
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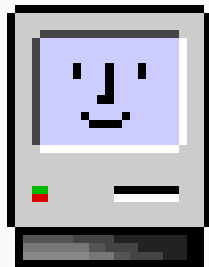
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- Apple looked at Intel's long forgotten Extensible Firmware Interface (EFI)

- EFI was similar to Apple's OFI, but it worked on Intel processors and had plenty of more features

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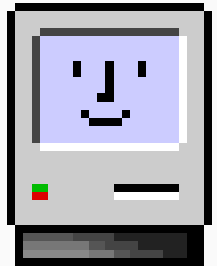- Thanks Apple! You popularized EFI and made booting x86 suck less!

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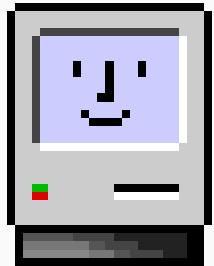- Thanks Apple! You popularized EFI and made booting x86 suck less!

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Hello World EFI-Style

```c
#include <efi.h>
#include <efilib.h>

EFI_STATUS
EFIAPI
efi_main (EFI_HANDLE Handle, EFI_SYSTEM_TABLE *Table)
{
    InitializeLib(Handle, Table);
    Print(L"Hello, world!\n");
    return EFI_SUCCESS;
}
```

Booting Linux

So this is all great, how does Linux boot?

1. First, the compressed Linux kernel (`vmlinuz`) is loaded by the bootloader and started

2. The Linux kernel then loads a file system called `initrd` into memory which contains just enough programs to mount your disk and load drivers

3. The kernel flag `root` specifies where your root partition is located to be mounted

4. Once the root partition is mounted, `/etc/fstab` is read to determine any other partitions to be mounted

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So what is /bin/init?

- **init** is the process with PID 1; it is the super-parent process of every process started on your system
- If **init** were to die, the kernel would panic
- Historically, System V style **init** programs would start a shell script located at /etc/rc that then loads your programs and desktop environment
- Most /etc/rc files use modularized shell scripts under /etc/rc.d or /etc/init.d to start services
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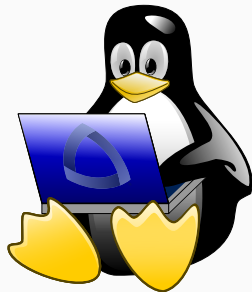
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