Linux Booting Procedure
How Linux boot?

Power-up / Reset

System startup

Stage 1 bootloader

Stage 2 bootloader

Kernel

Init

BIOS / BootMonitor

Master Boot Record

LILO, GRUB, etc.

Linux

User-space
What is “boot”?

• boot (n.)

Brief etymology

• Phrase “pull oneself up by one’s bootstraps”
  • Misattributed (at latest in 1901!) to “The Surprising Adventures of Baron Munchausen” (1781, Rudolf Erich Raspe) : The baron pulls himself out of a swamp by his hair (pigtail).
  • The use of this phrase is found in 1834 in the U.S.
  • “[S]omeone is attempting or has claimed some ludicrously far-fetched or impossible task”

• In the 20\textsuperscript{th} century, the “\textit{possible task}” meaning has appeared
  • “To begin an enterprise or recover from a setback without any outside help; to succeed only on one's own effort or abilities”

Bootstrapping (in Computer)

- The process of loading the basic software (typically, operating systems) into the main memory from persistent memory (HDD, flash ROM, etc.)
- “Boot” is an abbreviation for “bootstrap(ping)”
System startup
Booting sequence

1. Tern on
2. CPU jump to address of BIOS (0xFFFF0)
3. BIOS runs POST (Power-On Self Test)
4. Find bootable devices
5. Loads and execute boot sector form MBR
6. Load OS
BIOS (Basic Input/Output System)

- BIOS refers to the software code run by a computer when first powered on.
- The primary function of BIOS is code program embedded on a chip that recognises and controls various devices that make up the computer.
How computer startup?

- Booting is a bootstrapping process that starts operating systems when the user turns on a computer system.
- A boot sequence is the set of operations the computer performs when it is switched on that load an operating system.
Boot loader
MBR (Master Boot Record)

- OS is booted from a hard disk, where the Master Boot Record (MBR) contains the primary boot loader
- The MBR is a 512-byte sector, located in the first sector on the disk (sector 1 of cylinder 0, head 0)
- After the MBR is loaded into RAM, the BIOS yields control to it.
MBR (Master Boot Record)
The first 446 bytes are the primary boot loader, which contains both executable code and error message text.

The next sixty-four bytes are the partition table, which contains a record for each of four partitions.

The MBR ends with two bytes that are defined as the magic number (0xAA55). The magic number serves as a validation check of the MBR.
Boot loader

- Boot loader could be more aptly called the kernel loader. The task at this stage is to load the Linux kernel.
- Optional, initial RAM disk.
- GRUB and LILO are the most popular Linux boot loader.
## Other boot loader (Several OS)

- bootman
- GRUB
- LILO
- NTLDR
- XOSL
- BootX
- loadlin
- Gujin
- Boot Camp
- Syslinux
- GAG
Boot loader

• “It is responsible for loading and transferring control to the operating system *kernel* software (such as the **Hurd** or Linux).”[^4]

• Boot loader
  - BIOS (PC)
  - UEFI (Universal Extensible Firmware Interface) (PC)
    - “Secure Boot” issue
  - Das U-Boot (Universal bootloader) (for embedded systems)

• Second-stage boot loader
  - LILO (Linux Loader, Ver. 24.0, Released on Jun 7, 2013)
    - Supports GPT and RAID (!?)
  - GRUB2 (Ver. 2.00, Jun 26, 2012)
    - Supports BIOS and UEFI boot
    - GRUB Legacy (Grand Unified Boot Loader, Ver. 0.97, May 8, 2005)
  - ELILO (EFI Linux Boot Loader, Ver 3.16, Mar 29, 2013)
    - Originally for EFI and Itanium; currently bug fix only
  - SYSLINUX (Ver. 6.02, Oct 13, 2013)
  - NTLDR, BOOTMGR (beginning from Windows Vista)

GRUB: GRand Unified Bootloader

- GRUB is an operating system independent boot loader
- A multiboot software packet from GNU
- Flexible command line interface
- File system access
- Support multiple executable format
- Support diskless system
- Download OS from network
- Etc.
GRUB boot process

1. The BIOS finds a bootable device (hard disk) and transfers control to the master boot record.
2. The MBR contains GRUB stage 1. Given the small size of the MBR, Stage 1 just load the next stage of GRUB.
3. GRUB Stage 1.5 is located in the first 30 kilobytes of hard disk immediately following the MBR. Stage 1.5 loads Stage 2.
4. GRUB Stage 2 receives control, and displays to the user the GRUB boot menu (where the user can manually specify the boot parameters).
5. GRUB loads the user-selected (or default) kernel into memory and passes control on to the kernel.
What loads and what is loaded

**Power On**

- BIOS
- GRUB2
- BIOS/NIC Option ROM
- U-Boot

**HDD**
- (MBR)
- PXELINUX (a part of SYSLINUX)
- Network (tftp)

**Flash ROM**
- HDD
- Network
- SD Card
- etc...

**bzImage**
- Linux
- ulmage
GRUB

• **boot.img (512 byte)**
  - Usually located in the first sector (MBR) in HDD
  - Loaded at 0x7c00 by BIOS
  - Real-mode
  - Loads the next sector from HDD
    - The position is embedded by the GRUB installer (in sector, **blue** part)
    - Typically, at Sector 1 (the next sector)

• **core.img**
  - Located at the gap sectors between MBR and the first partition
  - The first partition begins at the 63rd sector (traditionally) or at 1MB (recently, as seen in right)
  - The first sector in core.img loads the remaining part of core.img from HDD

```bash
# dd if=/dev/vda count=1 bs=512 2> /dev/null | od -t x1 -A x
```

Jump!

Boot sector signature
Kernel
Kernel image

- The kernel is the central part in most computer operating systems because of its task, which is the management of the system's resources and the communication between hardware and software components.
- Kernel is always stored on memory until the computer is turned off.
- Kernel image is not an executable kernel, but a compressed kernel image.
- zImage size less than 512 KB.
- bzImage size greater than 512 KB.
Task of kernel

- Process management
- Memory management
- Device management
- System call
References

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https://www.slideshare.net/shimosawa/linux-kernel-booting-process-1-for-nlkb