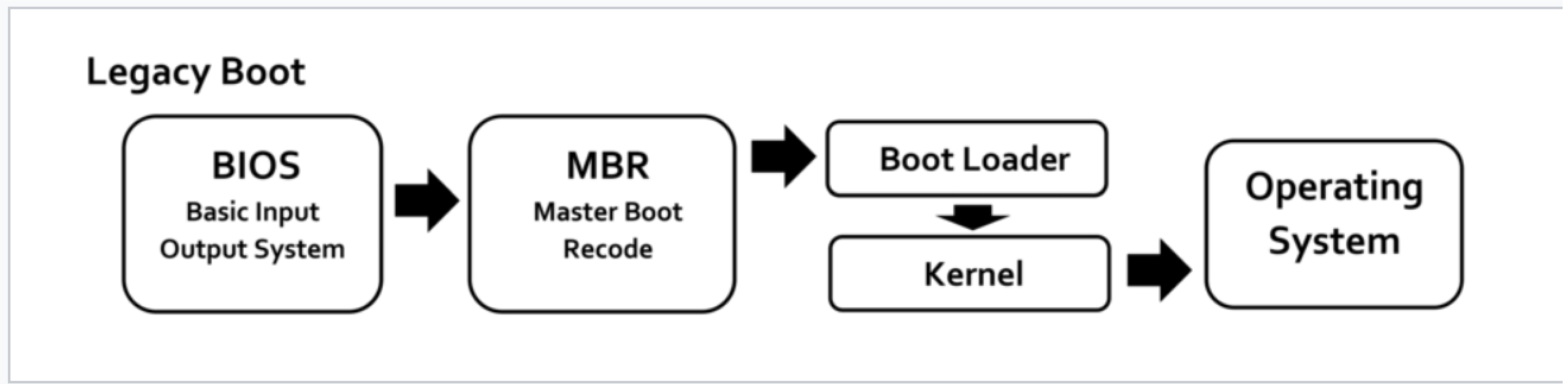


Legacy Boot

BIOS
Basic Input
Output System

MBR
Master Boot
Recode

Boot Loader

Kernel

Operating
System

Boot

Question

- *What does the content of "/boot" directory?*

Question

- *What does the content of “/boot” directory?*

Files required to boot the system

Question

- *How operating system boots?*

✓Booting the system is done by loading the kernel into main memory, and starting its execution.

✓The CPU is given a reset event, and the instruction register is loaded with a predefined memory location, where execution starts.

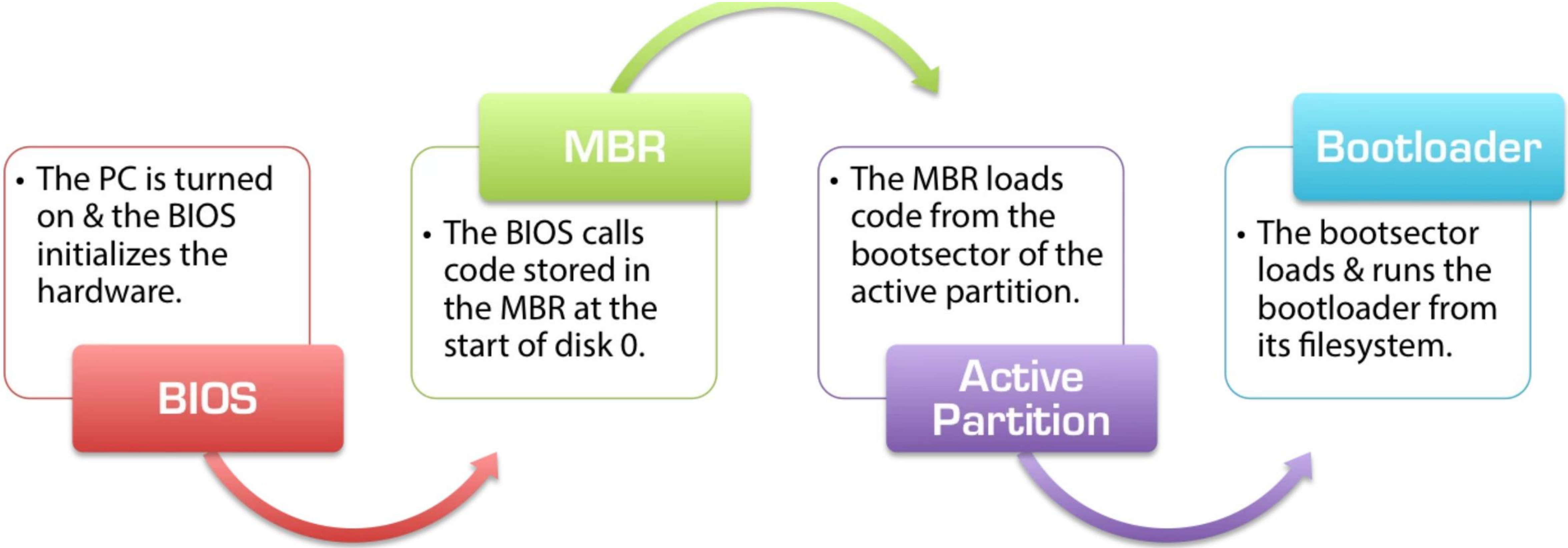
✓The initial bootstrap program is found in the BIOS read-only memory.

✓This program can run diagnostics, initialize all components of the system, loads and starts the Operating System loader. (Called **boot strapping**)

✓The loader program loads and starts the operating system.

When the Operating system starts, it sets up needed data structures in memory, sets several registers in the CPU, and then creates and starts the first user level program. From this point, the operating system only runs in response to interrupts. See CPU Response to Interrupts.

Boot sequence for all standard computers



BIOS

- The PC is turned on & the BIOS initializes the hardware.

MBR

- The BIOS calls code stored in the MBR at the start of disk 0.

Active Partition

- The MBR loads code from the bootsector of the active partition.

Bootloader

- The bootsector loads & runs the bootloader from its filesystem.

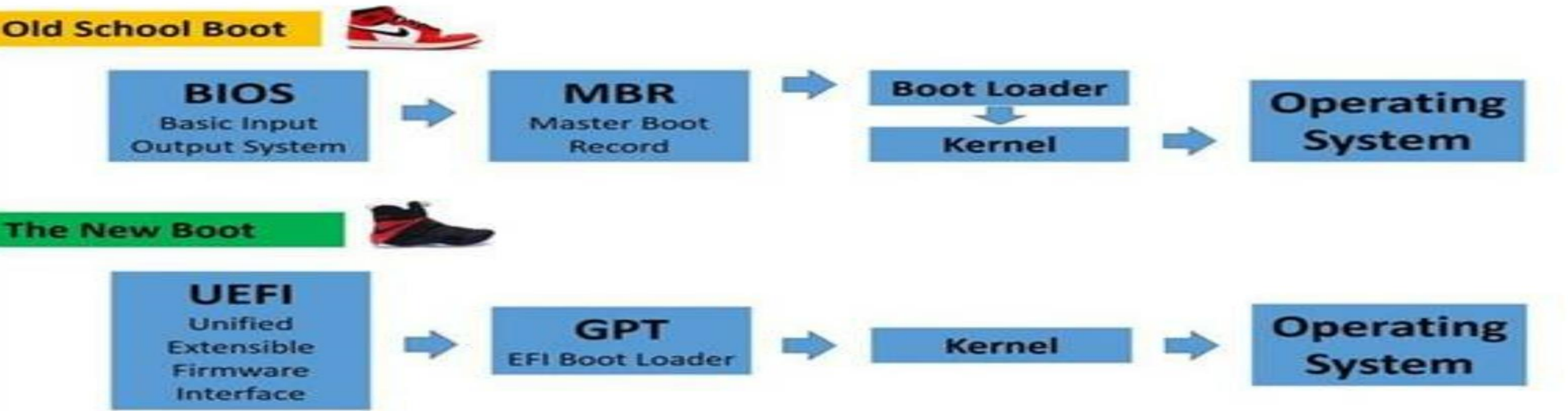
What is BIOS?

- BIOS stands for “Basic Input/Output System”, and is a type of firmware stored on a chip on your motherboard. When you start your computer, the computers boots the BIOS, which configures your hardware before handing off to a boot device (usually your hard drive).

P.S. Regardless of the computer or operating system, standard (“IBM-compatible”) desktop PCs and laptops all power on and start up using one of two ways

the traditional BIOS-MBR method and the newer UEFI-GPT method, used by the latest versions of Windows, Linux, and Mac OS X on newer PCs, laptops, and tablets.

BIOS vs UEFI

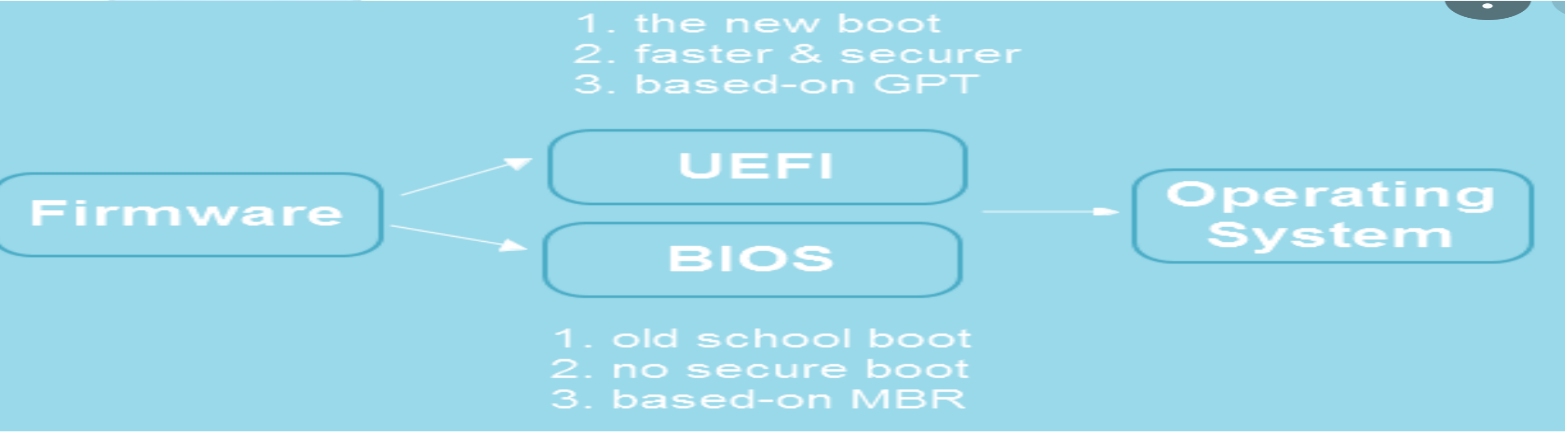


Old School Boot

BIOS Basic Input Output System → MBR Master Boot Record → Boot Loader → Kernel → Operating System

The New Boot

UEFI Unified Extensible Firmware Interface → GPT EFI Boot Loader → Kernel → Operating System



1. the new boot
2. faster & securer
3. based-on GPT

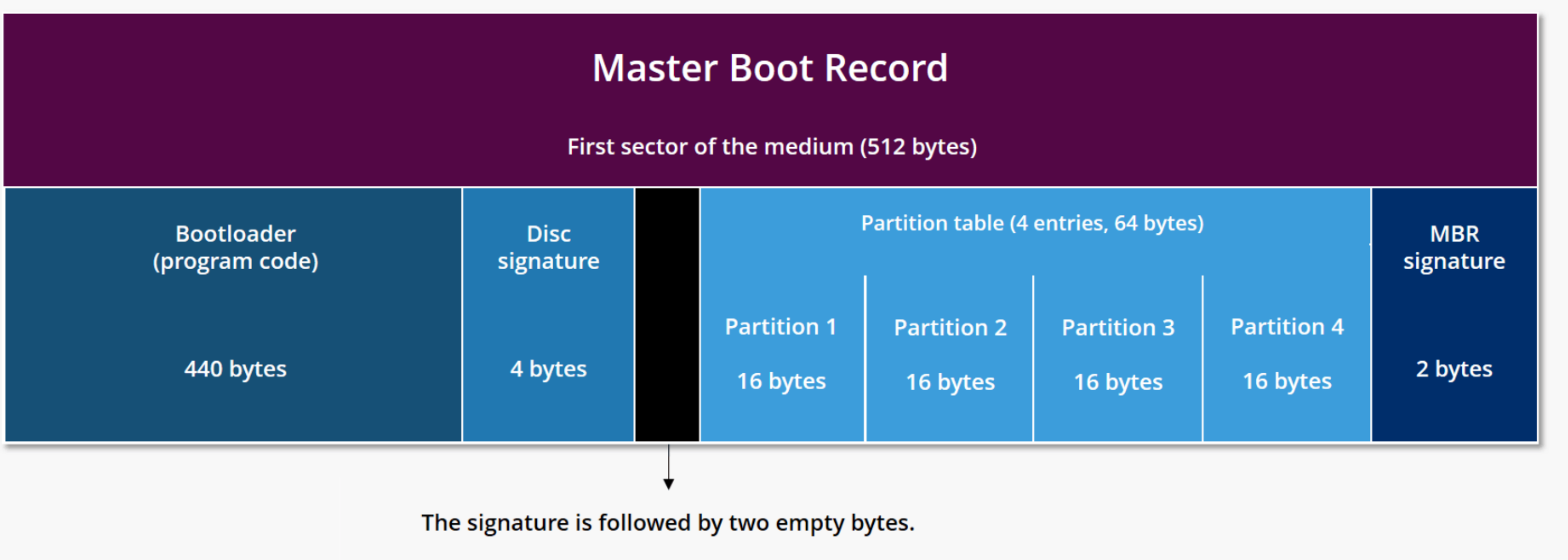
Firmware → UEFI / BIOS → Operating System

1. old school boot
2. no secure boot
3. based-on MBR

What is Master Boot Record (MBR)?

- Master boot record is always located at cylinder 0, head 0, and sector 1, the first sector on the disk.
- When a computer starts and the BIOS boots the machine, it will always look at this first sector for instructions and information on how to proceed with the boot process and load the operating system. The master boot record contains the following structures:
- **Master Partition Table:** This small bit of code that is referred to as a table contains a complete description of the partitions that are contained on the hard disk. When the developers designed the size of this master partition table, they left just enough room for the description of four partitions, hence the four partition (four physical partitions) limit. For this reason, and no other, a hard disk may only have four true partitions, also called *primary or physical partitions*. Any additional partitions must be logical partitions that are linked to (or are part of) one of the primary partitions. One of these partitions is marked as active, indicating that it is the one that the computer should used to continue the boot process.
- **Master Boot Code:** The master boot record is the small bit of computer code that the BIOS loads and executes to start the boot process. This code, when fully executed, transfers control to the boot program stored on the boot (active) partition to load the operating system.

What is Master Boot Record (MBR)?



Master Boot Record

First sector of the medium (512 bytes)

Bootloader (program code)

440 bytes

Disc signature

4 bytes

Partition table (4 entries, 64 bytes)

Partition 1

16 bytes

Partition 2

16 bytes

Partition 3

16 bytes

Partition 4

16 bytes

MBR signature

2 bytes

The signature is followed by two empty bytes.

What is CMOS and its usage?

CMOS Battery

What is CMOS and its usage?

CMOS stands for “Complementary Metal Oxide Semiconductor.” The CMOS battery powers the BIOS firmware in your laptop.

BIOS needs to remain operational even when your computer isn’t plugged into a power source. That’s where the battery comes in. When your computer gets unplugged, BIOS relies on the CMOS battery for power.

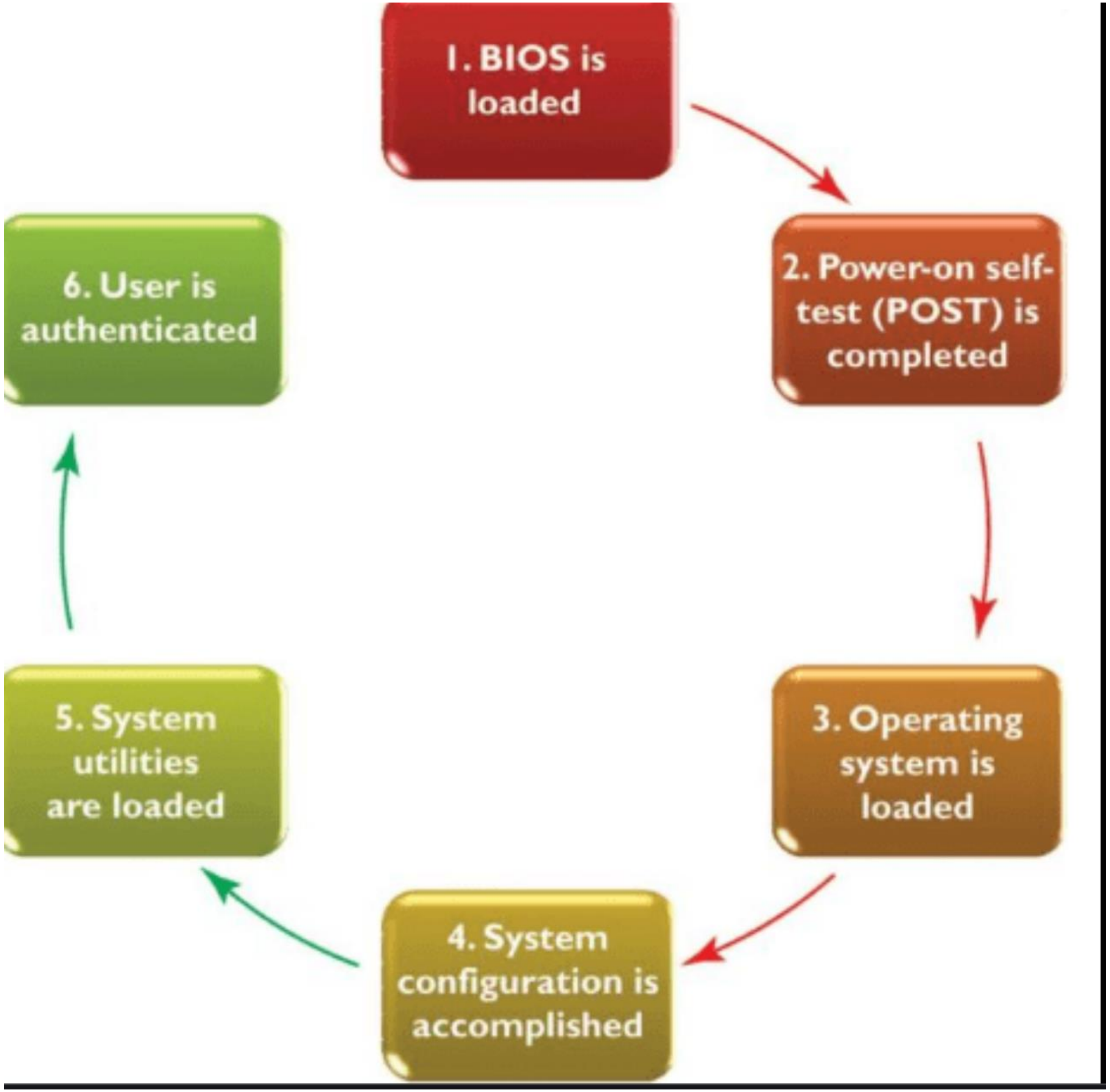
You’ll find CMOS batteries in both laptops and desktop PCs, but it’s used more frequently in a laptop. That’s because laptops are usually unplugged for a longer amount of time than desktop PCs. Most desktop PCs are unplugged from their power source very infrequently.

Why is System Boot Process required?

Why is System Boot Process required?

Without the system boot process, the computer users would have to download all the software components, including the ones not frequently required. With the system boot, only those software components need to be downloaded that are legitimately required and all extraneous components are not required. This process frees up a lot of space in the memory and consequently saves a lot of time.

Booting Process Steps



1. BIOS is loaded

2. Power-on self-test (POST) is completed

3. Operating system is loaded

4. System configuration is accomplished

5. System utilities are loaded

6. User is authenticated

What is a bootloader?

What is a bootloader?

A bootloader, also known as a boot program or bootstrap loader, is a **special operating system software** that loads into the working memory of a computer after start-up. For this purpose, immediately after a device starts, a bootloader is generally launched by a bootable medium like a hard drive, a CD/DVD or a USB stick. The boot medium receives information from the computer’s **firmware** (e.g. BIOS) about where the bootloader is. The whole process is also described as “booting”.

Find bootloader

You can use these commands to determine whether you're using GRUB or LILO:

```
$ sudo dd if=/dev/sda bs=512 count=1 2>&1 | grep GRUB
$ sudo dd if=/dev/sda bs=512 count=1 2>&1 | grep LILO
```

OR

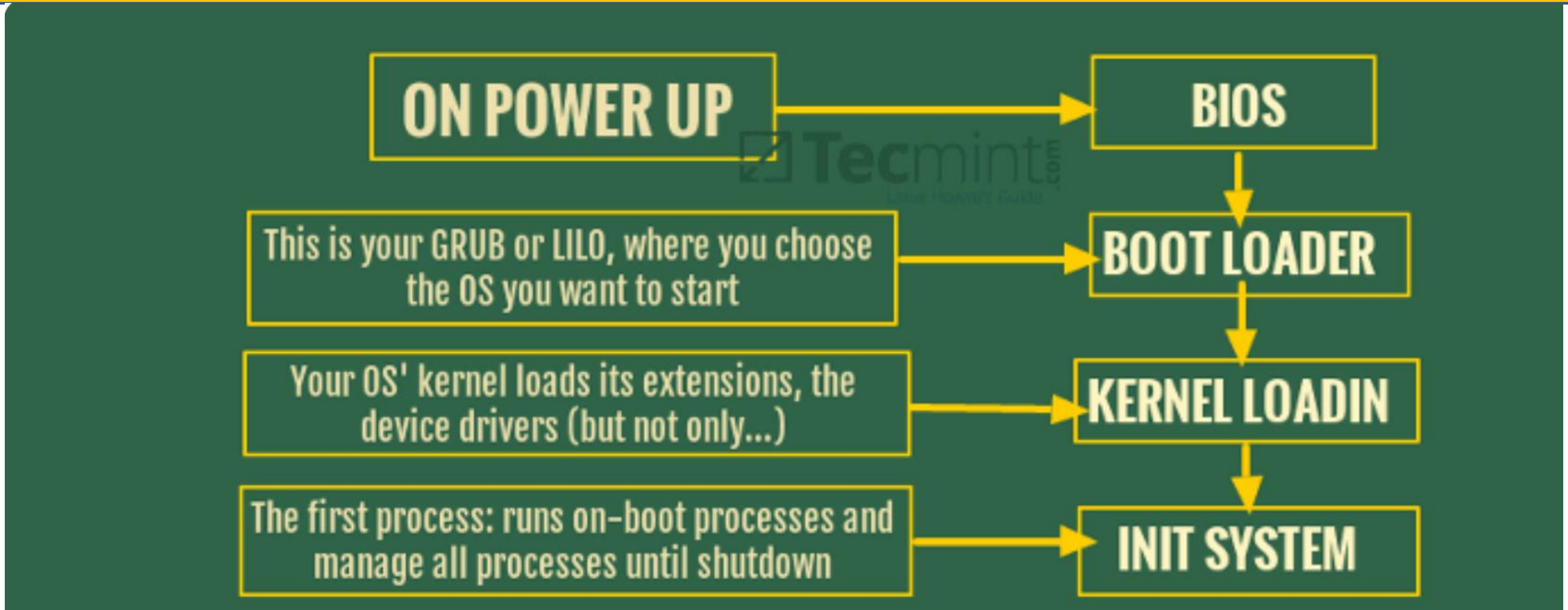
Using bootinfoscript

- `sudo ./bootinfoscript --stdout`

What is a init?

In Linux and other Unix-like operating systems, the **init** (initialization) process is the first process executed by the kernel at boot time. It has a process **ID** (**PID**) of **1**, it is executed in the background until the system is shut down.

The **init** process starts all other processes, that is daemons, services and other background processes, therefore, it is the mother of all other processes on the system. A process can start many other child processes on the system, but in the event that a parent process dies, **init** becomes the parent of the orphan process.



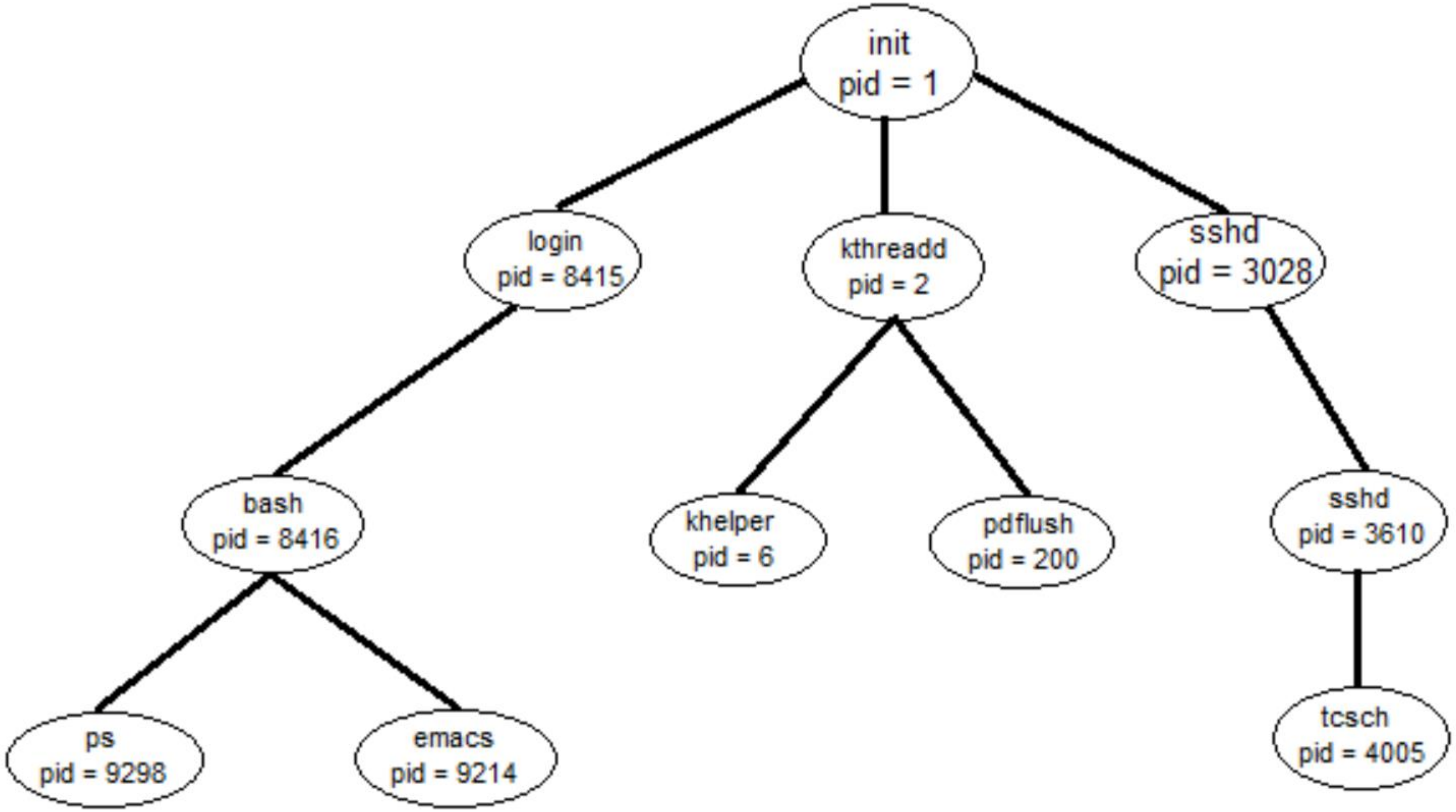
ON POWER UP → BIOS

This is your GRUB or LILO, where you choose the OS you want to start → BOOT LOADER

Your OS' kernel loads its extensions, the device drivers (but not only...) → KERNEL LOADIN

The first process: runs on-boot processes and manage all processes until shutdown → INIT SYSTEM

What is a init?



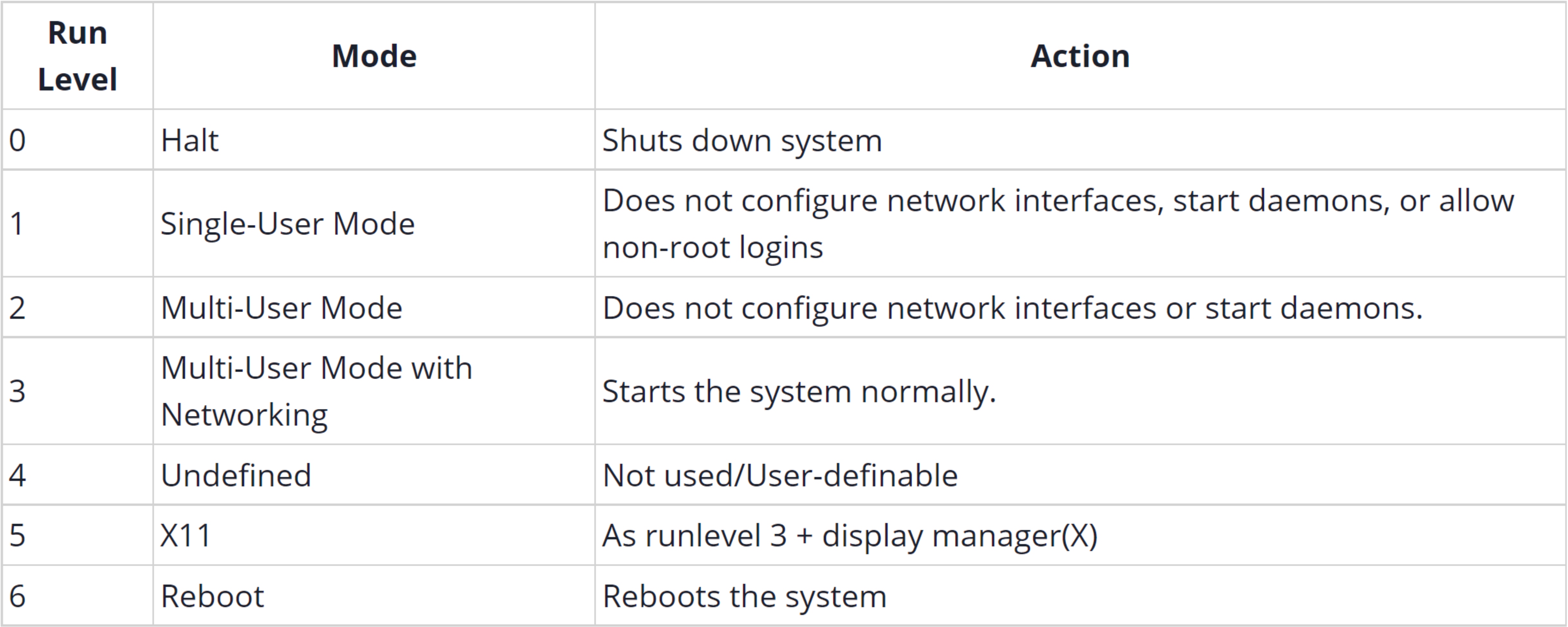
What is Run Level?

What is Run Level?

A **runlevel** is one of the modes that a Unix-based, dedicated server or a VPS server OS will run on. Each runlevel has a certain number of services stopped or started, giving the user control over the behavior of the machine. Conventionally, seven runlevels exist, numbered from zero to six.

After the Linux kernel has booted, the init program reads the **/etc/inittab** file to determine the behavior for each runlevel. Unless the user specifies another value as a kernel boot parameter, the system will attempt to enter (start) the default runlevel.

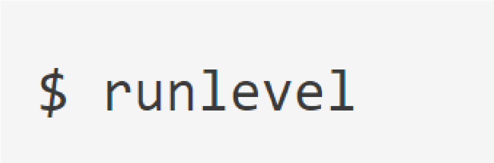
What is Run Level?



Run Level	Mode	Action
0	Halt	Shuts down system
1	Single-User Mode	Does not configure network interfaces, start daemons, or allow non-root logins
2	Multi-User Mode	Does not configure network interfaces or start daemons.
3	Multi-User Mode with Networking	Starts the system normally.
4	Undefined	Not used/User-definable
5	X11	As runlevel 3 + display manager(X)
6	Reboot	Reboots the system

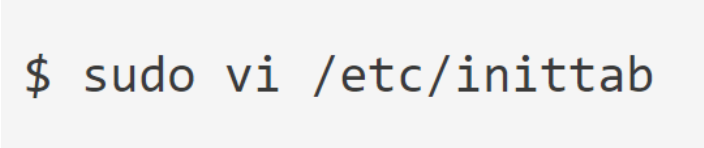
What is Run Level?

- To find out the system runlevel, open your Terminal and run the following command:



```
$ runlevel
```

- If you'd like to change the RunLevel to something else, edit /etc/inittab file:



```
$ sudo vi /etc/inittab
```

References

- https://ostechnix.com/check-runlevel-linux/
- https://linuxconfig.org/how-to-check-a-current-runlevel-of-your-linux-system
- https://www.cyberciti.biz/tips/linux-changing-run-levels.html
- https://askubuntu.com/questions/24459/how-do-i-find-out-which-boot-loader-i-have
- https://en.wikipedia.org/wiki/Bootloader
- https://www.liquidweb.com/kb/linux-runlevels-explained/
- https://www.tutorialspoint.com/how-does-system-boot-work
- https://www.javatpoint.com/booting-in-operating-system