

# Orchestration of Operating System Start-up

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**ABSTRACT:** - BIOS handing over the process to handle Operating system booting to another entity is same in all operating systems architectures. But how the software entities are handling processes to bring up the Operating system is such an interesting topic and discussing all and all around processes to get a complete mechanism of Operating system booting. Here mainly concentrating on UNIX based Operating system booting process by comparing both the versions of 6 & 7. In both 6 & 7 OS booting initiated when we power on the machine then BIOS wakes up and it informs the MBR (Master Boot Record) to handle the remaining processes. MBR the sensitive and first partition in the primary/bootable device and MBR have internally three major partitions i.e. IPL (Initial Program Loader), PTI (Partitioning Table Information) and VC (Validation Check). Once MBR is fine then it handover the process to black screen i.e. GRUB (Grand Unified Boot Loader), GRUB knows about all the kernels information and it takes the responsibility to load the preferred kernel. Kernel which we called as heart of the operating system, once the process is handing over to the kernel it brings all the resources and services alive in the machine. Finally INIT in 6 & SYSTEMD in 7 are parents of all the processes and play a key role to handle the resources. This is what we know but once we dig into deep of this booting process we can understand how beautiful it is.

find the first instruction, it points to the address of the instructions to execute and the address is in non-volatile memory. But these details are not such enough; we have to look into the hardware level at Microcontrollers to understand the clear process of booting. Microcontroller starts works when we just power on the system, once the power is balanced then microcontroller to the reset vector for the location where the start-up instruction can be found.

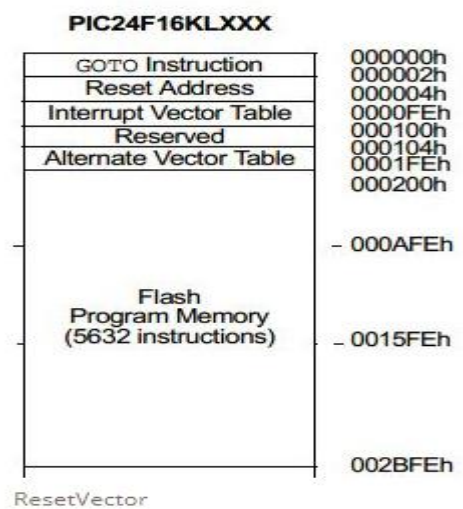


Figure: Reset vector location

## 1. INTRODUCTION:-

This Paper mainly focused on how operating system is loading through various processes. Operating system is the platform where all the programs come together to perform computational job. Operating systems do not directly work with hardware but it works with kernel to complete the tasks smoothly. Kernel directly interacts with the hardware to allocate the memory space to execute the tasks. Once task has been completed again control came to the operating system level, So Operating system is the user interface which acts as platform for human to execute computational tasks. We have to understand the operating system working principle first we have to know operating system loads into the memory. Here mainly focusing on UNIX based operating systems start up.

## 2. INITIAL STAGE:-

System memory is empty when we turn on PC, no processing of data and nothing to execute but components should know where to look for it. So BIOS manufacturers developed their code to always start executing at the same place i.e. reset vector. Reset vector is the default location a central processing unit will go to

Microcontroller loads the address where the instructions stored i.e. reset vector and the instructions are loaded and executed by the CPU. First vector table (register) information which is stored in flash memory is copied to RAM. One reason for copying the vector table information to RAM is that, RAM executes faster than the flash and this helps to decrease the latency of any interrupt calls within the system.

Date section of the linker handles all the handover processes. Once data is copied into RAM (.data Section), data initialization would be static & global variables. Along with the .data section .bss section is also copied and this section contains the variables that are initialized to zero. Any of the RAM functions will copy from flash to RAM with the microcontrollers at last. This entire process is called as "C Copy Down". Proper setup is only possible by performing this "copy down". Now the process is handover to the MBR which we called as Master Boot record and below BIOS setup decides the first boot device as hard disk.



Figure: Hard disk is selected as first boot device at BIOS level.

### 3. MASTER BOOT RECORD (MBR):-

Consistent "Starting Point" should have in every hard disk where all the key information stored about the disk such as number of partitions and type of file systems such like to load the operating system, BIOS has to load the initial boot program in some location and that place where all booting information is stored is called Master boot sector, MBR or boot sector.

The most important part MBR exists on the first sector (0\*00) in the HDD. It boots the device and loads the operating system in to memory. While installing operating system on the hardware this disk data structure will create once disk is partitioned. Disk partition is referred as partitioning the single hard drive into many logical drives and the partition is a contiguous set of blocks on the drive that treated as independent disk. Partitioning helps data to encapsulate since file system corruption is limited to that partition only. We can't find MBR in non-partitioned storage devices like floppy disk. As told initially MBR consists of the partition table of the disk and finds the active disk which is referred as active partition. Information related to the type and size of the partitions such like information holded by the MBR. Current standard size of this MBR disk partition is 512 bytes.

Physically it is located in in Sector 0; first sector which is 512 bytes long. Bootstrap information, partitioning table information and validation check or disk signatures are main parts of MBR. Bootstrap as boot loader, it is an executable code which is responsible to find the active partition table and to catch the first sector in active partition. After scanned the active partition a copy of the boot sector will be loaded to the memory to start the booting process. If MBR fails to finish its functions then different types of errors will be reported. BIOS can restore the MBR to the first block location on the hard disk from the MBR Image. BIOS use different methods to handle MBR data corruption in the situation of invalid MBR's.

Next 64 bytes data structure is partition table which contains all information of the hard disk partitions. To

find the active partition table has to analyse. MBR allows only one active partition for booting process. If more than one active partition exists then MBR will return an error message. Active partition loads files into memory. Validation check or boot record signature is located at the end of the MBR that can be also named as Magic Number. It contains only two bytes of memory which is required by the BIOS during booting.

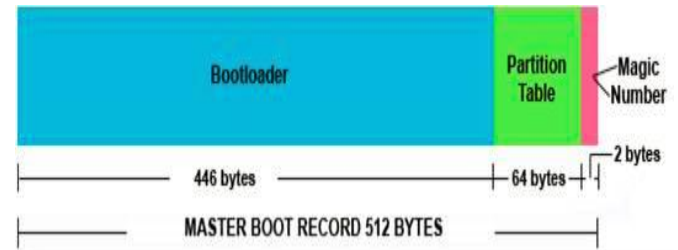


Figure: - Master Boot Record

MBR is to extract required data from HDD. In case of any duplicate or malicious MBR exists that overwrite the basic original MBR information and MBR is essential part of the computer which locates first sector of the disk and controls booting process.

### 4. GRAND UNIFIED BOOT LOADER (GRUB):-

GRUB is a software program which lists out all the Operating systems and Kernels available in the computer. Once know about the primary partition GRUB loads into the memory which tries to load the operating system with the help of initrd which is responsible to keep RAM disk for the loading Operating system. One of the most important functions of the grub is to load the kernel into memory. Next portion of the booting is controlled by the GRUB which provides interactive interface to choose which OS or the version of the kernel within an existing OS. Currently there are two grub versions available i.e. GRUB & GRUB2. We can customize grub configurations by changing the grub configuration file which mainly locates in /etc/grub/; we have to over look into it.

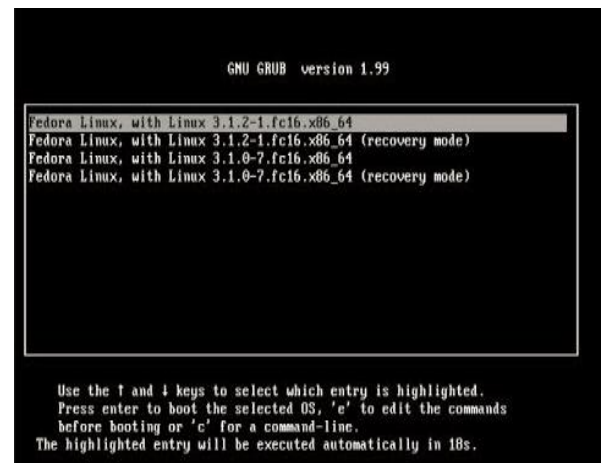


Figure: Grub Program listing out all the available OS Versions in the Computer

The first two values specifying what's going to be first and what the default Operating system is and Kernel when we are booting which is identified by the value "zero". Showing two kernels of the same Operating system. Let's see overview of GRUB configuration file,

```

default=0
timeout=5
splashimage=(hd0,0)/grub/splash.xpm.gz
hiddenmenu
0 → title Red Hat Enterprise Linux Server (2.6.32-358.6.2.el6.x86_64)
    root (hd0,0)
    kernel /vmlinuz-2.6.32-358.6.2.el6.x86_64 ro root=/dev/mapper/vg_virtualrhel-lv_root nomodeset rd_NO_LUKS KEYBOARDTYPE=pc KEYTABLE=us LANG=en_US.UTF-8 rd_NO_MD SYSFONT=latacyryheb-sun16 rd_LVM_LV=virtualrhel/lv_root rd_LVM_LV=v_virtualrhel/lv_swap rd_NO_DM rhgb quiet crashkernel=auto
    initrd /initramfs-2.6.32-358.6.2.el6.x86_64.img
1 → title Red Hat Enterprise Linux (2.6.32-358.el6.x86_64)
    root (hd0,0)
    kernel /vmlinuz-2.6.32-358.el6.x86_64 ro root=/dev/mapper/vg_virtualrhel-lv_root nomodeset rd_NO_LUKS KEYBOARDTYPE=pc KEYTABLE=us LANG=en_US.UTF-8 rd_NO_MD SYSFONT=latacyryheb-sun16 rd_LVM_LV=v_virtualrhel/lv_root rd_LVM_LV=v_virtualrhel/lv_swap rd_NO_DM rhgb quiet
    initrd /initramfs-2.6.32-358.el6.x86_64.img
  
```

Figure: Grub Configuration file

**default:** Which defines which Operating System or Kernel to be load automatically.

**Timeout:** Time which we get all the OS & Kernel information in the black screen. Once we exceed this time operating system loads automatically which defined at default option.

**Hiddenmenu:** It is not showing complete menu just countdown.

**Root (hd0, 0):** Location of the hard disk where kernel is located.

**Kernel:** Details of the Kernel.

**initrd:** Initial RAM Disk is initial root file system which is mounted before the original root file system available.

**Root=/dev/mapper/vg\_virtualrhel-lv\_root:** Root partition location.

**rd\_LVM\_LV:** Identifies and activates the logical volumes.

**rhgb quiet:** hides the boot messages by default.

Just have a look into the figure which is listing two versions of the same operating system at grub level. Default is listed as 0, so first operating system will load into the memory once booting crosses the GRUB level. If we want to change the default OS then we have to make that default value as 1 or else than depending on how many operating systems available in our machine. Basically next versions of the operating system overcome the problem of the previous problems and we can achieve new releases features in already installed OS by installing new release of the kernel.

**6. KERNEL:-**

Once Grub loads the Kernel in to Memory initrd acts as temporary mount for root filesystem. From here Kernel

takes the responsibility to bring up the Operating system. Kernel is the main component and called it as heart of the operating system which acts as interface between OS applications and hardware to schedule the jobs and to allocate the memory space for the jobs execution. Kernel is responsible for Process, Device, Memory management, interrupt handling and I/O Communication. Kernel executes the /sbin/init script which is the first process and PID 1. Init (Initialization) program brings up all the necessary services and looks into /etc/inittab file to bring up the operating system in defaults run level. There are 6 run levels which describe operating system states 0, 1, 2,3,4,5 & 6.

Run level	Description
0	Halt
1	Single User Mode
2	Multi User Mode without NFS
3	Multi user mode with NFS
4	Unused Mode
5	Graphical Mode X11
6	Reboot

From all the above listed run levels; single user mode is the power full mode where we can fix the issues more efficiently than the other modes. We can treat it as console mode as by CLI. We can fix the maximum issues of the operating from this mode.

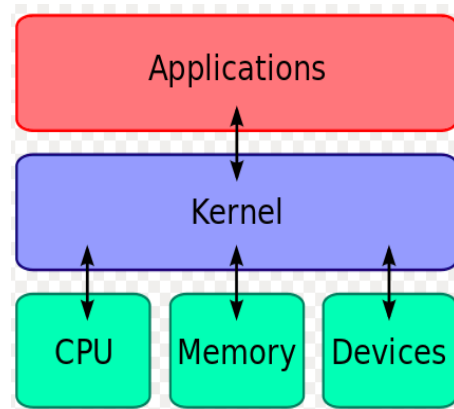


Figure: - Kernel

**7. DIFFERENTIATING RHEL 6 & 7 START UP:-**

Both RHEL 6 & 7 start up's are likely similar but we have to know few more things about what are the better features in RHEL 7 than RHEL 6. Kernel was upgraded in RHEL 7 and it is using systemd as initial process which is responsible to bring up all the remaining processes and we can't get the default run level from inittab file, we have to look into "/etc/systemd/system/default.target" for it. Memory management is extremely nice in RHEL 7 operating system than the RHEL 6.

## 8. CONCLUSION:-

All essential processes have been covered in this paper and sequence of the start-up is likely same for all the UNIX versions. In every version or release these processes handling mechanism have been changes to make the memory management more efficiently than the previous releases. GRUB2 is introduced in RHEL 7 & SUSE operating systems; it has more capability to handle the processes very smoothly. I will look into GRUB2 features and its mechanism how it handles the processes more efficiently in my next paper.

## TERMS:-

**Microcontroller** – It is an integrated circuit design to perform the specific operation which includes processor, memory (RAM), & IO peripherals in single circuit chip.

**Boot Strap** – It is program which initiates OS Start Up.

**MBR** – Primary partition in boot device.

**GRUB** – Software program which know all available operating systems in the machine.

**INIT** – First process in RHEL 6 Operating system, its PID is 1.

**SYSTEMD** – First process in RHEL 7 Operating system, its PID is 1.

## REFERENCES:-

No references for this, I got all this information from my industrial experience. I have been collected suitable figures from internet.

## BIOGRAPHY:-



G.K. Santan was born in Andhrapradesh, India in 1991. He received B.tech degree in Computer Science and Engineering from JNTU Hyderabad in 2012 and M.tech in Computer Networks and securities from KL University in 2014.

On the same year he started his career as GNOC Engineer in JDA Software Pvt Ltd, Bangalore, India, to Manage Global Data centre environments. He is expertise in UNIX based operating systems, Physical Machines Configurations, VMWare, KVM, and Scripting along with the Automation. He is certified as Redhat system administrator & Redhat Virtualization Administrator. After he moved to Atos Global IT services, Bangalore, India, as senior systems engineer.