Computer Operating Systems

Practice Session 2: Booting Sequence and /proc File System

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Today

Operating Systems, PS 2

- PC Booting Sequence
- Master Boot Record - MBR
- Preloading Sectors
- Linux /proc directory

When you press the power button...

- The system which starts the PC after the power button is pressed is called the boot loader (e.g. BIOS (**B**asic **I**nput **O**utput **S**ystem))
- BIOS is a series of information which is stored on hardware (ROM).

Initial processes

First checks and operations:

- Power Good Signal is the signal that is generated when the power supply reaches its required operating conditions (which is typically +5V).
- CPU is ready for operating. The First place to look up is the BIOS ROM for the start up program. Typically, the ROM ends with the memory space including the *jump* command.
- The First operation the BIOS performs is to check the system: a process called Power On Self Test (POST).The hardware is checked for any potential malfunction before the system starts.
- The graphics card is started via searching for its BIOS.

BIOS checks

ROMs of the remaining peripherals is searched for a BIOS.

- Typically, the BIOSes of the IDE/ATA hard drives are found and executed.
- If any other peripheral has a BIOS, then it is also executed similarly.

Startup screen

BIOS visualizes its startup screen. This startup screen contains the following information:

- BIOS producer and version number
- BIOS date
- Keys to enter the BIOS Setup
- System logo
- BIOS serial number
- `http://www.wimsbios.com/` (an online BIOS scan)

BIOS tests

- BIOS performs various tests on system such as memory count test.
- The user is informed on any errors encountered at this point.
- “*Keyboard not found, press F1 to continue...*”

Persistent system information

- After previous operations, BIOS reads the system date, system time and peripherals list from the CMOS memory on the mainboard.
- CMOS integrated circuits require very low power, thus they are able to store their memories for very extended periods with a standard battery. In PCs, CMOS integrated circuits are typically used for storing the data such as date and time, which need to be unaffected from power failures.
- By reading the information stored in the CMOS, the PC learns which hard drives are connected and in which order they should be checked for a proper startup sequence. Therefore, it is able to start the operating system properly.

Master Boot Record

- If the booting will be performed using a hard drive, Cylinder 0, Head 0, Sector 1 which is called *Master Boot Record* is read.
- At this point, BIOS is disengaged.
- In order to load the OS, system copies the first 512 bytes of the first hard drive into the memory and executes the code existing at the beginning of this section. Information included is related to the further booting operations. That is why it is called MBR.

PC Booting Sequence

Up to this point, booting operations are independent of the installed operating system and are the same for all PCs.

Master Boot Record - MBR

- The organization of the MBR has a very standard structure irrespective of the type of the installed operating system:
  - First part of 446 bytes are reserved for the program code.
  - Latter 64 bytes includes a partition table containing 4 partitions.
  - Last 2 bytes includes a special number (magic number AA55). An MBR having a different number is not validated by BIOS and any operating system.

- Program starts booting sequence by looking at the partition table and deciding which partition to be used for the startup. Then, program transfer the flow control to the specified partitions preloading sector (boot sector).

Locations of the preloading sectors

- Preloading sectors are the first sectors of the hard discs (a.k.a. boot sectors). They provide a space (512 bytes) for the code to start the operating system in that portion. Additionally, they include some basic information on the file system.

- A valid preloding sector (likewise in MBR) includes a special number stored in last 2 bytes (AA55).

Linux Boot Loaders

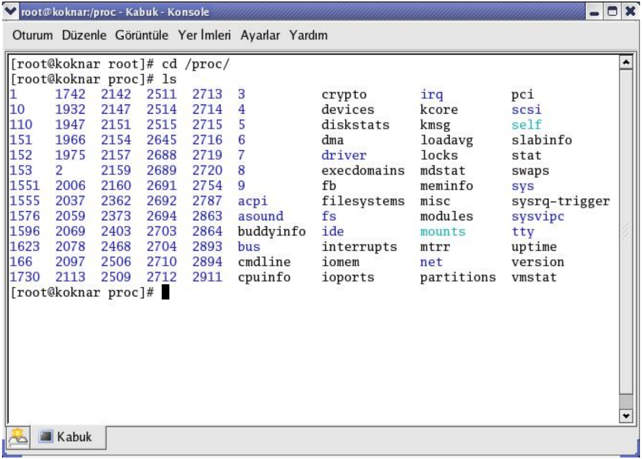
In Linux, different boot loaders can be written to different preloading sectors.

- LILO (Linux Loader) - GRUB (Grand Unified Boot Loader)
  - Are responsible for the loading of the system and conveying the control to the kernel.
  - Supports many operating systems and file systems.
- LILO (Linux Loader) - GRUB (Grand Unified Boot Loader) differences
  - LILO, does not provide interactive command interface like GRUB.
  - LILO does not support booting from network: GRUB does.
  - In LILO, with an erroneous modification in the config file, MBR with an improper configuration may cause the system to be un-bootable. In GRUB, on the occurrence of such condition, system passes to the interactive command interface.

Kernel functions and /proc

- Linux kernel has two basic functionalities:
  - Control the access to the hardware
  - Determine when and how the processes will interact with these entities
- /proc folder contains files about the current status of the kernel.
- Information about hardware and active processes can be retrieved from files under /proc directory.
- /proc folder is on the virtual file system.
- In virtual file systems, information is kept in memory: do not take any place in discs.
- In virtual file systems, files act and seem like usual files.

/proc directory contents

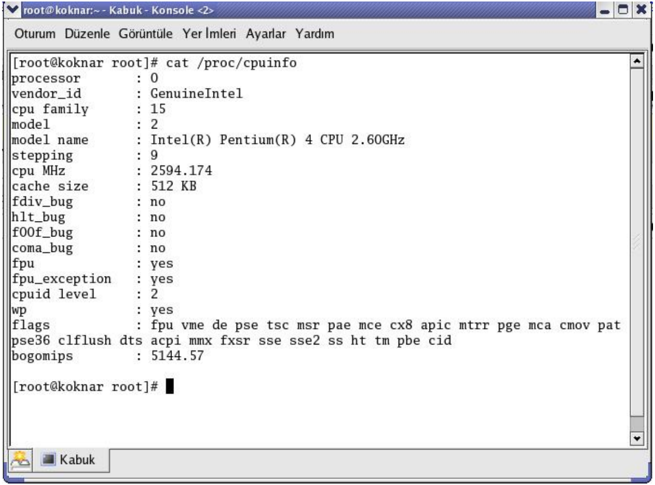

root@koknar:/proc - Kabuk - Konsole
Oturum Düzenle Görüntüle Yer İmleri Ayarlar Yardım
Kabuk

```
[root@koknar root]# cd /proc/
[root@koknar proc]# ls
1     1742  2142  2511  2713  3          crypto       irq         pci
10    1932  2147  2514  2714  4          devices      kcore       scsi
110   1947  2151  2515  2715  5          diskstats    kmsg        self
151   1966  2154  2645  2716  6          dma          loadavg     slabinfo
152   1975  2157  2688  2719  7          driver       locks       stat
153   2     2159  2689  2720  8          execdomains  mdstat      swaps
1551  2006  2160  2691  2754  9          fb           meminfo     sys
1555  2037  2362  2692  2787  acpi       filesystems  misc        sysrq-trigger
1576  2059  2373  2694  2863  asound     fs           modules     sysvipc
1596  2069  2403  2703  2864  buddyinfo  ide          mounts      tty
1623  2078  2468  2704  2893  bus        interrupts   mtrr        uptime
166   2097  2506  2710  2894  cmdline    iomem        net         version
1730  2113  2509  2712  2911  cpuinfo    ioports      partitions  vmstat
[root@koknar proc]# 
```

Properties of the files under /proc

- Files under /proc folder are updated continuously. Therefore:
  - Most of them always have size of 0 bytes.
  - The date and settings for the last access records of most of them reflect the current date and time.
- Most of the files are accessible to only 'root'.
- Files under /proc folder include many information about the system. Such as:
  - uptime, version, kcore (displays a value given in bytes representing the size of the physical memory)...
  - `cat /proc/cpuinfo`

Accessing CPU information

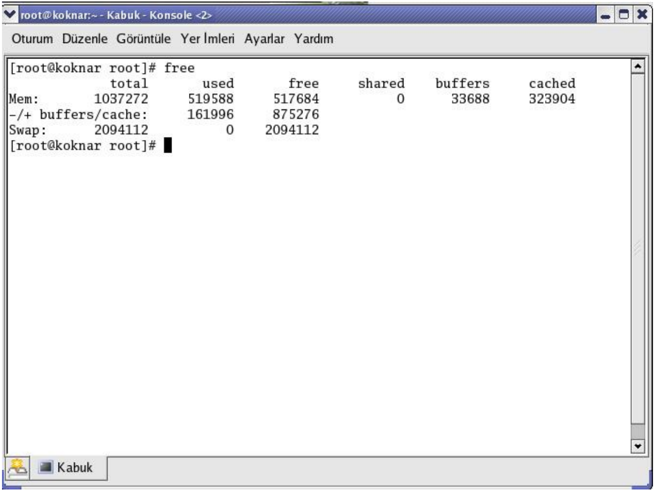

root@koknar:~ - Kabuk - Konsole <2>
Oturum Düzenle Görüntüle Yer İmleri Ayarlar Yardım
Kabuk

```
[root@koknar root]# cat /proc/cpuinfo
processor       : 0
vendor_id       : GenuineIntel
cpu family      : 15
model           : 2
model name      : Intel(R) Pentium(R) 4 CPU 2.60GHz
stepping        : 9
cpu MHz         : 2594.174
cache size      : 512 KB
fdiv_bug        : no
hlt_bug         : no
f00f_bug        : no
coma_bug        : no
fpu             : yes
fpu_exception   : yes
cpuid level     : 2
wp              : yes
flags           : fpu vme de pse tsc msr pae mce cx8 apic mtrr pge mca cmov pat
pse36 clflush dts acpi mmx fxsr sse sse2 ss ht tm pbe cid
bogomips        : 5144.57

[root@koknar root]# 
```

Monitoring memory space

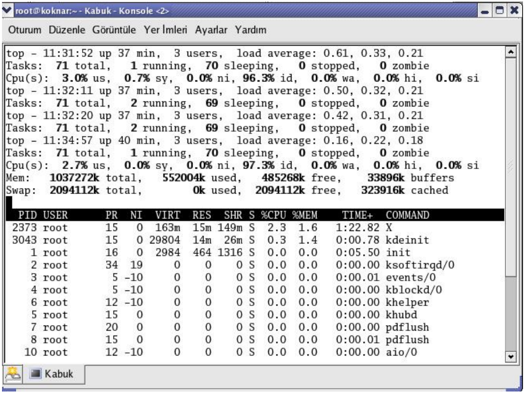
- Some files under /proc are hard to read with naked eye. Therefore, we use auxiliary commands:
- Example: `free` gives information about memory space:
  - Swap space
  - Free and used portions of the physical memory
  - Buffers and cache consumed by the kernel

free command


root@koknar:~ - Kabuk - Konsole <2>
Oturum Düzenle Görüntüle Yer İmleri Ayarlar Yardım
Kabuk

```
[root@koknar root]# free
             total       used       free     shared    buffers     cached
Mem:       1037272     519588     517684          0      33688     323904
-/+ buffers/cache:     161996     875276
Swap:      2094112          0    2094112
[root@koknar root]#
```

top command


root@koknar:~ - Kabuk - Konsole <2>
Oturum Düzenle Görüntüle Yer İmleri Ayarlar Yardım
Kabuk

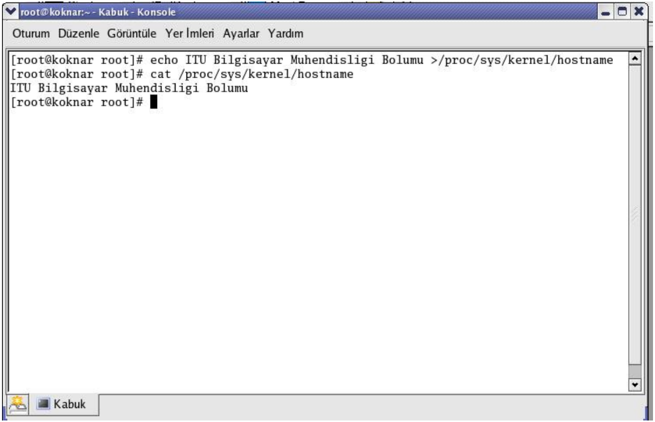
```
top - 11:31:52 up 37 min,  3 users,  load average: 0.61, 0.33, 0.21
Tasks:  71 total,   1 running,  70 sleeping,   0 stopped,   0 zombie
Cpu(s):  3.0% us,  0.7% sy,  0.0% ni, 96.3% id,  0.0% wa,  0.0% hi,  0.0% si
top - 11:32:11 up 37 min,  3 users,  load average: 0.50, 0.32, 0.21
Tasks:  71 total,   2 running,  69 sleeping,   0 stopped,   0 zombie
top - 11:32:20 up 37 min,  3 users,  load average: 0.42, 0.31, 0.21
Tasks:  71 total,   2 running,  69 sleeping,   0 stopped,   0 zombie
top - 11:34:57 up 40 min,  3 users,  load average: 0.16, 0.22, 0.18
Tasks:  71 total,   1 running,  70 sleeping,   0 stopped,   0 zombie
Cpu(s):  2.7% us,  0.0% sy,  0.0% ni, 97.3% id,  0.0% wa,  0.0% hi,  0.0% si
Mem:   1037272k total,   552004k used,   485268k free,    33896k buffers
Swap:  2094112k total,        0k used,  2094112k free,   323916k cached

  PID USER      PR  NI  VIRT  RES  SHR S %CPU %MEM    TIME+  COMMAND
 2373 root      15   0  163m  15m 149m S  2.3  1.6   1:22.82 X
 3043 root      15   0 29804  14m  26m S  0.3  1.4   0:00.78 kdeinit
    1 root      16   0  2984  464 1316 S  0.0  0.0   0:05.50 init
    2 root      34  19     0    0    0 S  0.0  0.0   0:00.00 ksoftirqd/0
    3 root       5 -10     0    0    0 S  0.0  0.0   0:00.01 events/0
    4 root       5 -10     0    0    0 S  0.0  0.0   0:00.00 kblockd/0
    6 root      12 -10     0    0    0 S  0.0  0.0   0:00.00 khelper
    5 root      15   0     0    0    0 S  0.0  0.0   0:00.00 khubd
    7 root      20   0     0    0    0 S  0.0  0.0   0:00.00 pdflush
    8 root      15   0     0    0    0 S  0.0  0.0   0:00.01 pdflush
   10 root      12 -10     0    0    0 S  0.0  0.0   0:00.00 aio/0
```

- PR: Priority level
- NI: Nice parameter, used in scheduling (Negative values - higher priority)
- VIRT: Virtual memory space used by the process
- SHR: How much virtual memory can be shared
- RES: Usage of the physical memory

Writing into the files under/proc

- Most of the time, these files are read-only.
- Some of them may be modified in order to configure some kernel parameters.
- Since the files are virtual, shell commands are needed for performing the modifications.

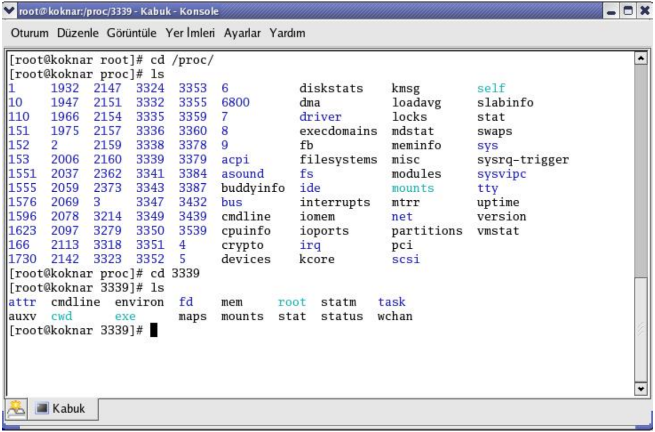
Writing to a file under /proc using echo command


root@koknar:~ - Kabuk - Konsole
Oturum Düzenle Görüntüle Yer İmleri Ayarlar Yardım
Kabuk

```
[root@koknar root]# echo ITU Bilgisayar Muhendisligi Bolumu >/proc/sys/kernel/hostname
[root@koknar root]# cat /proc/sys/kernel/hostname
ITU Bilgisayar Muhendisligi Bolumu
[root@koknar root]#
```

Process folders under /proc

- Each running process has a folder under /proc.


root@koknar:/proc/3339 - Kabuk - Konsole
Oturum Düzenle Görüntüle Yer İmleri Ayarlar Yardım
Kabuk

```
[root@koknar root]# cd /proc/
[root@koknar proc]# ls
1     1932  2147  3324  3353  6          diskstats    kmsg        self
10    1947  2151  3332  3355  6800       dma          loadavg     slabinfo
110   1966  2154  3335  3359  7          driver       locks       stat
151   1975  2157  3336  3360  8          execdomains  mdstat      swaps
152   2     2159  3338  3378  9          fb           meminfo     sys
153   2006  2160  3339  3379  acpi       filesystems  misc        sysrq-trigger
1551  2037  2362  3341  3384  asound     fs           modules     sysvipc
1555  2059  2373  3343  3387  buddyinfo  ide          mounts      tty
1576  2069  3     3347  3432  bus        interrupts   mtrr        uptime
1596  2078  3214  3349  3439  cmdline    iomem        net         version
1623  2097  3279  3350  3539  cpuinfo    ioports      partitions  vmstat
166   2113  3318  3351  4     crypto     irq          pci
1730  2142  3323  3352  5     devices    kcore        scsi
[root@koknar proc]# cd 3339
[root@koknar 3339]# ls
attr  cmdline  environ  fd    mem     root  statm   task
auxv  cwd      exe      maps  mounts  stat  status  wchan
[root@koknar 3339]# █
```

References

- http://www.redhat.com/docs/manuals/linux/RHL-9-Manual/ref-guide/ch-proc.html
- http://www.kernelnewbies.org/documents/kdoc/procfs-guide/lkprocfsguide.html
- http://www.redhat.com/docs/manuals/linux/RHL-9-Manual/ref-guide/s1-proc-topfiles.html
- http://www.belgeler.org/