101.1 Determine and configure hardware settings

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Key knowledge areas

- Enable and disable integrated peripherals.
- Differentiate between the various types of mass storage devices.
- Determine hardware resources for devices.
- Tools and utilities to list various hardware information (e.g. lsusb, lspci, etc.).
- Tools and utilities to manipulate USB devices.
- Conceptual understanding of sysfs, udev and dbus.

Partial list of the used files, terms and utilities

- /sys/
- /proc/
- /dev/
- modprobe
- lsmod
- lspci
- lsusb

/dev/
Hardware devices are made available through special files under the /dev directory.

/proc/
The process information pseudo-filesystem

/sys/
The mount point for sysfs providing a set of virtual files by exporting information about various kernel subsystems, hardware devices and associated device drivers from the kernel's device model to user space.

lsmod
Prints the contents of the /proc/modules file

lspci
Prints detailed information about all PCI buses and devices in the system

lsusb
Prints detailed information about all USB buses and devices in the system

modprobe
Used to add a loadable kernel module (LKM) to the Linux kernel or to remove an LKM from the kernel

swap space
Used when the amount of physical memory (RAM) is full. If the system needs more memory resources and the RAM is full, inactive pages in memory are moved to the swap

space.

Uname

Show system information:

- Kernel name
- Host name
- Kernel release
- Kernel version
- Processor
- Hardware platform
- Operating system

```
uname -a
Linux localhost.localdomain 5.11.22-100.fc32.x86_64 #1 SMP Wed May 19 18:58:25
UTC 2021 x86_64 x86_64 x86_64 GNU/Linux
```

```
$uname -s
Linux
$uname -n
localhost.localdomain
$uname -r
5.11.22-100.fc32.x86_64
$uname -v
#1 SMP Wed May 19 18:58:25 UTC 2021
$uname -m
x86_64
$uname -p
x86_64
$uname -i
x86_64
$uname -o
GNU/Linux
```

CPU

The central processing unit (CPU) is the brain of the computer, where the instructions to perform calculations or manipulate data are processed. Most common is the 64-bit x86_64 type, and decreasingly, the 32-bit x86 type.

- lscpu
- cat /proc/cpuinfo
- dmesg | grep CPU
- dmidecode -t processor

```
$lscpu
Architecture:                    x86_64
CPU op-mode(s):                  32-bit, 64-bit
Byte Order:                      Little Endian
Address sizes:                   39 bits physical, 48 bits virtual
CPU(s):                          4
On-line CPU(s) list:             0-3
Thread(s) per core:              2
```

```
Core(s) per socket:              2
Socket(s):                       1
NUMA node(s):                    1
Vendor ID:                       GenuineIntel
CPU family:                      6
Model:                           126
Model name:                      Intel(R) Core(TM) i3-1005G1 CPU @ 1.20GHz
Stepping:                        5
CPU MHz:                         1200.000
CPU max MHz:                     3400.0000
CPU min MHz:                     400.0000
BogoMIPS:                        2380.80
Virtualization:                  VT-x
L1d cache:                       96 KiB
L1i cache:                       64 KiB
L2 cache:                        1 MiB
L3 cache:                        4 MiB
NUMA node0 CPU(s):               0-3
Vulnerability Itlb multihit:     KVM: Mitigation: VMX disabled
Vulnerability L1tf:              Not affected
Vulnerability Mds:               Not affected
Vulnerability Meltdown:          Not affected
Vulnerability Spec store bypass: Mitigation; Speculative Store Bypass disabled
via prctl and seccomp
Vulnerability Spectre v1:        Mitigation; usercopy/swapgs barriers and __user
pointer sanitization
Vulnerability Spectre v2:        Mitigation; Enhanced IBRS, IBPB conditional, RSB
filling
Vulnerability Srbds:             Not affected
Vulnerability Tsx async abort:   Not affected
Flags:                           fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pat pse36 lflush
                                 dts acpi mmx fxsr sse sse2 ss ht tm pbe syscall nx pdpe1gb rdtscp lm constant_
                                 tsc art arch_perfmon pebs bts rep_good nopl xtopology nonstop_tsc cpuid aperfmp
                                 erf tsc_known_freq pni pclmulqdq dtes64 monitor ds_cpl vmx est tm2 ssse3 sdbg f
                                 ma cx16 xtpr pdcm pcid sse4_1 sse4_2 x2apic movbe popcnt tsc_deadline_timer aes
                                 xsave avx f16c rdrand lahf_lm abm 3dnowprefetch cpuid_fault epb invpcid_single
                                 ssbd ibrs ibpb stibp ibrs_enhanced tpr_shadow vnmi flexpriority ept vpid ept_a
                                 d fsgsbase tsc_adjust sgx bmi1 avx2 smep bmi2 erms invpcid avx512f avx512dq rds
                                 eed adx smap avx512ifma clflushopt intel_pt avx512cd sha_ni avx512bw avx512vl x
                                 saveopt xsavec xgetbv1 xsaves split_lock_detect dtherm ida arat pln pts hwp hwp
                                 _notify hwp_act_window hwp_epp hwp_pkg_req avx512vbmi umip pku ospke avx512_vbm
                                 i2 gfni vaes vpclmulqdq avx512_vnni avx512_bitalg avx512_vpopcntdq rdpid sgx_lc
                                 fsrm md_clear flush_l1d arch_capabilities
```

```
$cat /proc/cpuinfo
processor      : 0
vendor_id      : GenuineIntel
cpu family     : 6
model          : 126
model name     : Intel(R) Core(TM) i3-1005G1 CPU @ 1.20GHz
stepping       : 5
microcode      : 0xa0
cpu MHz        : 1460.101
cache size     : 4096 KB
physical id    : 0
siblings       : 4
core id        : 0
cpu cores      : 2
apicid         : 0
initial apicid : 0
fpu            : yes
fpu_exception  : yes
cpuid level    : 27
wp             : yes
flags          : fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pat
pse36 clflush dts acpi mmx fxsr sse sse2 ss ht tm pbe syscall nx pdpe1gb rdtscp
lm constant_tsc art arch_perfmon pebs bts rep_good nopl xtopology nonstop_tsc
cpuid aperfmperf tsc_known_freq pni pclmulqdq dtes64 monitor ds_cpl vmx est tm2
ssse3 sdbg fma cx16 xtpr pdcm pcid sse4_1 sse4_2 x2apic movbe popcnt
tsc_deadline_timer aes xsave avx f16c rdrand lahf_lm abm 3dnowprefetch
cpuid_fault epb invpcid_single ssbd ibrs ibpb stibp ibrs_enhanced tpr_shadow vnmi
flexpriority ept vpid ept_ad fsgsbase tsc_adjust sgx bmi1 avx2 smep bmi2 erms
invpcid avx512f avx512dq rdseed adx smap avx512ifma clflushopt intel_pt avx512cd
sha_ni avx512bw avx512vl xsaveopt xsavec xgetbv1 xsaves split_lock_detect dtherm
ida arat pln pts hwp hwp_notify hwp_act_window hwp_epp hwp_pkg_req avx512vbmi
umip pku ospke avx512_vbmi2 gfni vaes vpclmulqdq avx512_vnni avx512_bitalg
```

```
avx512_vpopcntdq rdpid sgx_lc fsrm md_clear flush_l1d arch_capabilities
vmx flags      : vnmi preemption_timer posted_intr invvpid ept_x_only ept_ad
ept_1gb flexpriority apicv tsc_offset vtpr mtf vapic ept vpid unrestricted_guest
vapic_reg vid ple pml ept_mode_based_exec tsc_scaling
bugs           : spectre_v1 spectre_v2 spec_store_bypass swapgs itlb_multihit
bogomips       : 2380.80
clflush size   : 64
cache_alignment       : 64
address sizes  : 39 bits physical, 48 bits virtual
power management:
```

```
$dmesg | grep CPU
[    0.049885] smpboot: Allowing 4 CPUs, 0 hotplug CPUs
[    0.054550] setup_percpu: NR_CPUS:8192 nr_cpumask_bits:4 nr_cpu_ids:4
nr_node_ids:1
[    0.082625] SLUB: HWalign=64, Order=0-3, MinObjects=0, CPUs=4, Nodes=1
[    0.094572] rcu:   RCU restricting CPUs from NR_CPUS=8192 to nr_cpu_ids=4.
[    0.097746] random: crng done (trusting CPU's manufacturer)
[    0.111581] mce: CPU0: Thermal monitoring enabled (TM1)
[    0.113734] smpboot: CPU0: Intel(R) Core(TM) i3-1005G1 CPU @ 1.20GHz (family:
0x6, model: 0x7e, stepping: 0x5)
[    0.114105] smp: Bringing up secondary CPUs ...
[    0.114105] .... node  #0, CPUs:      #1 #2 #3
[    0.115681] smp: Brought up 1 node, 4 CPUs
[ 3526.049955] Disabling non-boot CPUs ...
[ 3526.050646] IRQ 139: no longer affine to CPU1
[ 3526.051689] smpboot: CPU 1 is now offline
[ 3526.053521] IRQ 140: no longer affine to CPU2
[ 3526.055277] smpboot: CPU 2 is now offline
[ 3526.056983] IRQ 141: no longer affine to CPU3
[ 3526.058015] smpboot: CPU 3 is now offline
[ 3526.062628] Enabling non-boot CPUs ...
[ 3526.063790] CPU1 is up
[ 3526.064627] CPU2 is up
[ 3526.065368] CPU3 is up
```

```
# dmidecode -t processor
# dmidecode 3.2
Getting SMBIOS data from sysfs.
SMBIOS 3.1.1 present.

Handle 0x000F, DMI type 4, 48 bytes
Processor Information
        Socket Designation: U3E1
        Type: Central Processor
        Family: Core i3
        Manufacturer: Intel(R) Corporation
        ID: E5 06 07 00 FF FB EB BF
        Signature: Type 0, Family 6, Model 126, Stepping 5
        Flags:
                FPU (Floating-point unit on-chip)
                VME (Virtual mode extension)
                DE (Debugging extension)
                PSE (Page size extension)
                TSC (Time stamp counter)
                MSR (Model specific registers)
                PAE (Physical address extension)
                MCE (Machine check exception)
                CX8 (CMPXCHG8 instruction supported)
                APIC (On-chip APIC hardware supported)
                SEP (Fast system call)
                MTRR (Memory type range registers)
                PGE (Page global enable)
                MCA (Machine check architecture)
                CMOV (Conditional move instruction supported)
                PAT (Page attribute table)
                PSE-36 (36-bit page size extension)
                CLFSH (CLFLUSH instruction supported)
                DS (Debug store)
                ACPI (ACPI supported)
```

```
                MMX (MMX technology supported)
                FXSR (FXSAVE and FXSTOR instructions supported)
                SSE (Streaming SIMD extensions)
                SSE2 (Streaming SIMD extensions 2)
                SS (Self-snoop)
                HTT (Multi-threading)
                TM (Thermal monitor supported)
                PBE (Pending break enabled)
        Version: Intel(R) Core(TM) i3-1005G1 CPU @ 1.20GHz
        Voltage: 0.7 V
        External Clock: 100 MHz
        Max Speed: 1200 MHz
        Current Speed: 1200 MHz
        Status: Populated, Enabled
        Upgrade: Other
        L1 Cache Handle: 0x000C
        L2 Cache Handle: 0x000D
        L3 Cache Handle: 0x000E
        Serial Number: To Be Filled By O.E.M.
        Asset Tag: To Be Filled By O.E.M.
        Part Number: To Be Filled By O.E.M.
        Core Count: 2
        Core Enabled: 2
        Thread Count: 4
        Characteristics:
                64-bit capable
                Multi-Core
                Hardware Thread
                Execute Protection
                Enhanced Virtualization
                Power/Performance Control
```

RAM

The random access memory (RAM) of a system is used to temporarily store data and instructions for the operating system and the programs that are executing. The maximum amount of memory that can be used with a 32-bit processor is 4 GiB, whereas a 64-bit processor can theoretically use 16 EiB of memory.

If a system doesn't have sufficient RAM for the processes you are executing on it, then it will use virtual memory, called swap space in Linux. Swap space is hard drive space that is temporarily used to hold data that exceeds the amount of RAM available. If the system is using swap space constantly, then it will perform poorly.

- free
- cat /proc/meminfo
- lsmem

```
$free
               total        used        free      shared  buff/cache   available
Mem:         7648128     2387228     1049480      752052     4211420     4237076
Swap:        7811068           0     7811068

$free -h
               total        used        free      shared  buff/cache   available
Mem:           7.3Gi       2.3Gi       1.0Gi       718Mi       4.0Gi       4.1Gi
Swap:          7.4Gi          0B       7.4Gi
```

```
# lsmem
```

```
RANGE                                  SIZE  STATE REMOVABLE BLOCK
0x0000000000000000-0x000000004fffffff  1.3G online       yes   0-9
0x0000000100000000-0x000000029fffffff  6.5G online       yes 32-83

Memory block size:       128M
Total online memory:     7.8G
Total offline memory:      0B
```

```
$cat /proc/meminfo
MemTotal:        7648128 kB
MemFree:         1098584 kB
MemAvailable:    4285432 kB
Buffers:          301820 kB
Cached:          3748276 kB
SwapCached:            0 kB
Active:          1490632 kB
Inactive:        4067964 kB
Active(anon):      15428 kB
Inactive(anon):  2194044 kB
Active(file):    1475204 kB
Inactive(file):  1873920 kB
Unevictable:      549504 kB
Mlocked:            1880 kB
SwapTotal:       7811068 kB
SwapFree:        7811068 kB
Dirty:               212 kB
Writeback:             0 kB
AnonPages:       2057992 kB
Mapped:           718532 kB
Shmem:            720652 kB
KReclaimable:     129164 kB
Slab:             244136 kB
SReclaimable:     129164 kB
SUnreclaim:       114972 kB
KernelStack:       12272 kB
PageTables:        40608 kB
NFS_Unstable:          0 kB
Bounce:                0 kB
WritebackTmp:          0 kB
CommitLimit:    11635132 kB
Committed_AS:   10337864 kB
VmallocTotal:   34359738367 kB
VmallocUsed:       40124 kB
VmallocChunk:          0 kB
Percpu:             4192 kB
HardwareCorrupted:     0 kB
AnonHugePages:         0 kB
ShmemHugePages:        0 kB
ShmemPmdMapped:        0 kB
FileHugePages:         0 kB
FilePmdMapped:         0 kB
CmaTotal:              0 kB
CmaFree:               0 kB
HugePages_Total:       0
HugePages_Free:        0
HugePages_Rsvd:        0
HugePages_Surp:        0
Hugepagesize:       2048 kB
Hugetlb:               0 kB
DirectMap4k:      326844 kB
DirectMap2M:     6516736 kB
DirectMap1G:     2097152 kB
```

Observe the free results:

- Amount of mem 7G
- Free 1G
- Used 2.3G
- Where is the mem? 7-2.3 <> 1 !!
- dmiCheck the buffers/cache
- No swap memory is used

Firmware / Bios / UEFI

Firmware is software that has been written to non-volatile memory such as read-only memory (ROM) or flash memory. There are several types of firmware that may be present in a computer system. On each device that provides services to a system (like a network interface card or a graphics display), there is typically a ROM chip that contains firmware for the device.

The motherboard firmware contains the code that allows the integrated components of the system to work together. This firmware tests the components upon startup, identifies and initializes these components, and attempts to find a bootloader to load an operating system.

Originally, this firmware was known as the **Basic Input/Output System (BIOS)**, System ROM, or ROM BIOS. BIOS is used to provide basic services. Recently the firmware uses the **Unified Extensible Firmware Interface (UEFI)**; however, the functions of UEFI appear so similar to BIOS that many people still refer to the system firmware as BIOS.

Both UEFI-based systems and BIOS-based systems provide a proprietary menu program that allows integrated devices to be enabled or disabled, the **SETUP** menu. It selects what order the firmware will look for a bootable device.

If a system has UEFI firmware, then it may be more challenging to boot the Linux operating system due to a feature called **Secure Boot**. If Secure Boot is enabled, then the bootloader must be cryptographically signed by a digital key that is recognized by the firmware. If the bootloader is not properly signed, then booting may still be possible by disabling Secure Boot in the firmware settings, in favor of the Compatibility Support Module (CSM).

As advancements in integration of peripherals have occurred, more components have been placed on-board, meaning they are embedded into the motherboard of a system. These integrated peripherals can be managed through firmware as well.

Until the mid 2000s, the configuration utility was implemented in the BIOS (Basic Input/Output System), the standard for firmware containing the basic configuration routines found in x86 motherboards. From the end of the first decade of the 2000s, machines based on the x86 architecture started to replace the BIOS with a new implementation called UEFI (Unified Extensible Firmware Interface), which has more sophisticated features for identification, testing, configuration and firmware upgrades.

In the BIOS setup utility it is possible to enable and disable integrated peripherals, activate basic error protection and change hardware settings like IRQ (interrupt request) and DMA (direct memory access). Changing these settings is rarely needed on modern machines, but it may be necessary to make adjustments to address specific issues. If the machine is equipped with many storage devices, it is important to define which one has the correct bootloader and should be the first entry in the device boot order.

- dmidecode

```
# dmidecode  | less
```

```
# dmidecode 3.2
Getting SMBIOS data from sysfs.
SMBIOS 3.1.1 present.
Table at 0x000E2410.

Handle 0x0000, DMI type 222, 14 bytes
OEM-specific Type
        Header and Data:
                DE 0E 00 00 01 99 00 03 10 01 20 02 30 03
        Strings:
                Memory Init Complete
                End of DXE Phase
                BIOS Boot Complete

Handle 0x0001, DMI type 14, 8 bytes
Group Associations
        Name: Intel(R) Silicon View Technology
        Items: 1
                0x0000 (OEM-specific)
```

-s, --string KEYWORD
Only display the value of the DMI string identified by KEYWORD. KEYWORD must be a keyword from the following list: **bios-vendor, bios-version, bios-release-date, bios-revision, firmware-revision, system-manufacturer, system-product-name, system-version, system-serial-number, system-uuid, system-family, baseboard-manufacturer, baseboard-product-name, baseboard-version, baseboard-serial-number, baseboard-asset-tag, chassis-manufacturer, chassis-type, chassis-version, chassis-serial-number, chassis-asset-tag, processor-family, processor-manufacturer, processor-version, processor-frequency**. Each keyword corresponds to a given DMI type and a given offset within this entry type. Not all strings may be meaningful or even defined on all systems. Some keywords may return more than one result on some systems (e.g. processor-version on a multi-processor system). If KEYWORD is not provided or not valid, a list of all valid keywords is printed and dmidecode exits with an error. This option cannot be used more than once.

Note: on Linux, most of these strings can alternatively be read directly from sysfs, typically from files under /sys/devices/virtual/dmi/id. Most of these files are even readable by regular users.

-t, --type TYPE
Only display the entries of type TYPE. TYPE can be either a DMI type number, or a comma-separated list of type numbers, or a keyword from the following list: **bios, system, baseboard, chassis, processor, memory, cache, connector, slot**. Refer to the DMI TYPES section below for details. If this option is used more than once, the set of displayed entries will be the union of all the given types. If TYPE is not provided or not valid, a list of all valid keywords is printed and dmidecode exits with an error.

```
# dmidecode -t bios
# dmidecode 3.2
Getting SMBIOS data from sysfs.
SMBIOS 3.1.1 present.

Handle 0x0015, DMI type 13, 22 bytes
BIOS Language Information
        Language Description Format: Abbreviated
        Installable Languages: 1
                enUS
        Currently Installed Language: enUS

Handle 0x0010, DMI type 0, 26 bytes
BIOS Information
        Vendor: LENOVO
        Version: DJCN24WW
        Release Date: 01/14/2021
        ROM Size: 11 MB
        Characteristics:
                PCI is supported
                BIOS is upgradeable
                BIOS shadowing is allowed
```

```
            Boot from CD is supported
            Selectable boot is supported
            EDD is supported
            Print screen service is supported (int 5h)
            8042 keyboard services are supported (int 9h)
            Serial services are supported (int 14h)
            Printer services are supported (int 17h)
            ACPI is supported
            USB legacy is supported
            LS-120 boot is supported
            ATAPI Zip drive boot is supported
            BIOS boot specification is supported
            Function key-initiated network boot is supported
            Targeted content distribution is supported
            UEFI is supported
      BIOS Revision: 1.24
      Firmware Revision: 1.20
```

```
# dmidecode -s bios-vendor
LENOVO
# dmidecode -s bios-version
DJCN24WW
# dmidecode -s bios-release-date
01/14/2021
# dmidecode -s bios-revision
1.24
# dmidecode -s firmware-revision
1.20
```

Mass Storage Devices

There are quite a few mass storage interfaces that are still in use today:

The Small Computer **System Interface (SCSI)** is one of the oldest and requires a SCSI controller in the system to control one or more disk drives that connect to it.

The **Integrated Drive Electronics (IDE)** or **Parallel Advanced Technology Attachment (PATA)** type interface includes the controller directly on each drive and was very popular for hard disks through the 1990s. This type is still used for some optical drive devices today.

The most common interface used for internal mass storage devices today is the **Serial Advanced Technology Attachment (SATA)** type. Each SATA drive is connected directly to the system board by a cable. To configure the primary SATA drive, connect it with a cable to the connector of the system board that is designated as the primary port.

For external drives, the Universal Serial Bus (USB) interface is the most common, but there are other standards such as FireWire and Thunderbolt.

From Linux kernel version 2.4 onwards, most storage devices are now identified as if they were SCSI devices, regardless of their hardware type. IDE, SSD and USB block devices will be prefixed by ***sd*** (for example /dev/sda). he exception to this pattern occurs with memory cards (SD cards) and NVMe devices (SSD connected to the PCI Express bus). For SD cards, the paths are like /dev/mmcblk0p1. NVMe SSD devices receive the prefix nvme (, as in /dev/nvme0n1p1 and /dev/nvme0n1p2.

- df -h
- fdisk -l
- blkid
- lsblk
- lsscsi
- hdparm
- dmesg | grep sd

```
$ df -h
Filesystem      Size  Used Avail Use% Mounted on
overlay         196G  145G   42G  78% /
tmpfs            64M     0   64M   0% /dev
tmpfs            32G     0   32G   0% /sys/fs/cgroup
/dev/sda1       196G  145G   42G  78% /etc/hosts
shm              64M     0   64M   0% /dev/shm
tmpfs            32G     0   32G   0% /proc/acpi
tmpfs            32G     0   32G   0% /proc/scsi
tmpfs            32G     0   32G   0% /sys/firmware
```

```
# df -h
Filesystem               Size  Used Avail Use% Mounted on
devtmpfs                 3.7G     0  3.7G   0% /dev
tmpfs                    3.7G  137M  3.6G   4% /dev/shm
tmpfs                    3.7G  2.0M  3.7G   1% /run
/dev/mapper/fedora-root   49G   16G   31G  34% /
tmpfs                    3.7G   14M  3.7G   1% /tmp
/dev/nvme0n1p2           976M  231M  678M  26% /boot
/dev/mapper/fedora-home  177G   91G   77G  54% /home
/dev/nvme0n1p1           200M  8.6M  192M   5% /boot/efi
tmpfs                    747M  104K  747M   1% /run/user/1001
```

```
# fdisk -l
Disk /dev/nvme0n1: 238.49 GiB, 256060514304 bytes, 500118192 sectors
Disk model: SAMSUNG MZALQ256HAJD-000L2
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: gpt
Disk identifier: BFA8875E-2F5D-4504-812B-618CFD968EBD

Device           Start       End   Sectors   Size Type
/dev/nvme0n1p1    2048    411647    409600   200M EFI System
/dev/nvme0n1p2  411648   2508799   2097152     1G Linux filesystem
/dev/nvme0n1p3 2508800 500117503 497608704 237.3G Linux LVM
```

```
# blkid
/dev/nvme0n1p1: SEC_TYPE="msdos" UUID="7F70-2AC1" BLOCK_SIZE="512" TYPE="vfat"
PARTLABEL="EFI System Partition" PARTUUID="e556663a-ed3f-4d5b-b69e-0abe9158c16b"
/dev/nvme0n1p2: UUID="027d32d8-de03-40d5-ad80-453618bd71a8" BLOCK_SIZE="4096"
TYPE="ext4" PARTUUID="11ae4b81-2f10-4a68-a7cb-4c7fd2229678"
/dev/nvme0n1p3: UUID="VgZxLA-HigE-eyyU-DBHj-XbyP-e2gF-LEzdtR" TYPE="LVM2_member"
PARTUUID="d4560004-ae55-4c3c-adee-1729a188417e"
/dev/mapper/fedora-root: UUID="a00558ae-7865-4baa-b186-df0aaf2ab482"
BLOCK_SIZE="4096" TYPE="ext4"
/dev/mapper/fedora-swap: UUID="6cc2a9b5-50dd-4786-b0da-8239c67ed9ee" TYPE="swap"
/dev/mapper/fedora-home: UUID="06206a20-a62a-498e-a8d8-cd126855b435"
BLOCK_SIZE="4096" TYPE="ext4"
```

```
# lsblk
NAME            MAJ:MIN RM   SIZE RO TYPE MOUNTPOINT
nvme0n1         259:0    0 238.5G  0 disk
├─nvme0n1p1     259:1    0   200M  0 part /boot/efi
├─nvme0n1p2     259:2    0     1G  0 part /boot
```

```
└─nvme0n1p3     259:3    0 237.3G  0 part
  ├─fedora-root 253:0    0    50G  0 lvm  /
  ├─fedora-swap 253:1    0   7.5G  0 lvm  [SWAP]
  └─fedora-home 253:2    0 179.8G  0 lvm  /home
```

```
# lsblk
NAME   MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda      8:0    0  300G  0 disk
`-sda1   8:1    0  200G  0 part /etc/hosts
sr0     11:0    1 1024M  0 rom
```

```
# lsscsi
[N:0:5:1]    disk    SAMSUNG MZALQ256HAJD-000L2__1              /dev/nvme0n1

# lsscsi -v
[N:0:5:1]    dsk/nvm SAMSUNG MZALQ256HAJD-000L2__1              /dev/nvme0n1
  dir: /sys/class/nvme/nvme0/nvme0n1
[/sys/devices/pci0000:00/0000:00:1d.4/0000:03:00.0/nvme/nvme0/nvme0n1]
```

```
# dmesg | grep sd
[    0.008527] ACPI: SSDT 0x0000000048E9F000 001B61 (v02 LENOVO CpuSsdt  00003000 INTL 20180927)
[    0.008532] ACPI: SSDT 0x0000000048974000 00336C (v02 LENOVO SaSsdt   00003000 INTL 20180927)
[    0.008534] ACPI: SSDT 0x000000004896D000 00677B (v02 LENOVO TcssSsdt 00001000 INTL 20180927)
[    0.263094] ACPI: SSDT 0xFFFF9B8B80C37000 0000F4 (v02 PmRef  Cpu0Psd  00003000 INTL 20180927)
[    0.269532] ACPI: SSDT 0xFFFF9B8B80D89000 000AB0 (v02 PmRef  ApPsd    00003000 INTL 20180927)
[    0.718591] ahci 0000:00:17.0: flags: 64bit ncq sntf pm clo only pio slum part deso sadm sds apst
[26354.621777] sd 2:0:0:0: Attached scsi generic sg0 type 0
[26354.621843] sd 2:0:0:0: [sda] 60604416 512-byte logical blocks: (31.0 GB/28.9 GiB)
[26354.622251] sd 2:0:0:0: [sda] Write Protect is off
[26354.622259] sd 2:0:0:0: [sda] Mode Sense: 45 00 00 00
[26354.622472] sd 2:0:0:0: [sda] Write cache: disabled, read cache: enabled, doesn't support DPO or FUA
[26354.690005]  sda: sda1 sda2 sda3
[26354.691547] sd 2:0:0:0: [sda] Attached SCSI removable disk
[26411.298732] sda: detected capacity change from 60604416 to 0
```

```
# tree /dev/disk/
/dev/disk/
├── by-id
│   ├── dm-name-fedora-home -> ../../dm-2
│   ├── dm-name-fedora-root -> ../../dm-0
│   ├── dm-name-fedora-swap -> ../../dm-1
│   ├── dm-uuid-LVM-Ly5zp6Y155RnTEzxvilb9yYXtIhDcGrH6r4DWOyYTmspFPJzJCtjBAmfDPwcvg27 -> ../../dm-1
│   ├── dm-uuid-LVM-Ly5zp6Y155RnTEzxvilb9yYXtIhDcGrHPNXp1us9fnVHwun8MZSEfwVW3vE7GtLU -> ../../dm-0
│   ├── dm-uuid-LVM-Ly5zp6Y155RnTEzxvilb9yYXtIhDcGrHWEbZDpxRt6TPrH9em3dQNHQYJ3zouzhh -> ../../dm-2
│   ├── lvm-pv-uuid-VgZxLA-HigE-eyyU-DBHj-XbyP-e2gF-LEzdtR -> ../../nvme0n1p3
│   ├── nvme-eui.002538ab01d2bf96 -> ../../nvme0n1
│   ├── nvme-eui.002538ab01d2bf96-part1 -> ../../nvme0n1p1
│   ├── nvme-eui.002538ab01d2bf96-part2 -> ../../nvme0n1p2
│   ├── nvme-eui.002538ab01d2bf96-part3 -> ../../nvme0n1p3
│   ├── nvme-SAMSUNG_MZALQ256HAJD-000L2_S4ULNF2NB44121 -> ../../nvme0n1
│   ├── nvme-SAMSUNG_MZALQ256HAJD-000L2_S4ULNF2NB44121-part1 -> ../../nvme0n1p1
│   ├── nvme-SAMSUNG_MZALQ256HAJD-000L2_S4ULNF2NB44121-part2 -> ../../nvme0n1p2
│   └── nvme-SAMSUNG_MZALQ256HAJD-000L2_S4ULNF2NB44121-part3 -> ../../nvme0n1p3
├── by-partlabel
│   └── EFI\x20System\x20Partition -> ../../nvme0n1p1
├── by-partuuid
│   ├── 11ae4b81-2f10-4a68-a7cb-4c7fd2229678 -> ../../nvme0n1p2
│   ├── d4560004-ae55-4c3c-adee-1729a188417e -> ../../nvme0n1p3
│   └── e556663a-ed3f-4d5b-b69e-0abe9158c16b -> ../../nvme0n1p1
├── by-path
│   ├── pci-0000:03:00.0-nvme-1 -> ../../nvme0n1
│   ├── pci-0000:03:00.0-nvme-1-part1 -> ../../nvme0n1p1
│   ├── pci-0000:03:00.0-nvme-1-part2 -> ../../nvme0n1p2
│   └── pci-0000:03:00.0-nvme-1-part3 -> ../../nvme0n1p3
└── by-uuid
    ├── 027d32d8-de03-40d5-ad80-453618bd71a8 -> ../../nvme0n1p2
    ├── 06206a20-a62a-498e-a8d8-cd126855b435 -> ../../dm-2
    ├── 6cc2a9b5-50dd-4786-b0da-8239c67ed9ee -> ../../dm-1
    ├── 7F70-2AC1 -> ../../nvme0n1p1
    └── a00558ae-7865-4baa-b186-df0aaf2ab482 -> ../../dm-0
```

Hardware Resources

There are four types of hardware resources that devices use to communicate with the system. As some of these resources refer to input and output, part of their name may be abbreviated as IO. The four resources are: IO ports, IO memory, interrupt requests (IRQ), and direct memory access (DMA) channels:

- **IO Ports** - Memory addresses that allow for communication with hardware devices.
- **IO Memory** - A section or location that acts much like the RAM that is presented to the processor via the system bus. These are used to pass and store data as well as for access to devices on the system.

- **Interrupt Requests (IRQ)** - An interrupt is a hardware signal that pauses or stops a running program so that the interrupt handler can switch to running another program, or send and receive data. There are a set of commonly-defined interrupts called IRQ's that map to common interfaces, such as the system timer, keyboard controller, serial and parallel ports, and floppy controllers. The /proc/irq directory contains configuration information for each IRQ on the system.

- **Direct Memory Access (DMA)** - A method by which particular hardware items in the system can directly access RAM, without going through the CPU.

Commands:

- cat /proc/ioports
- cat /proc/iomem
- cat /proc/dma
- cat /proc/interrupts
- cat /proc/diskstats
- ls /proc
- lsipc
- lshw
- hwinfo

```
# cat /proc/ioports
0000-0cf7 : PCI Bus 0000:00
  0000-001f : dma1
  0020-0021 : pic1
  0040-0043 : timer0
  0050-0053 : timer1
  0060-0060 : keyboard
  0062-0062 : PNP0C09:00
    0062-0062 : EC data
  0064-0064 : keyboard
  0066-0066 : PNP0C09:00
...
```

```
# cat /proc/iomem
00000000-00000fff : Reserved
00001000-00001fff : System RAM
00002000-0000bfff : Reserved
0000c000-0005efff : System RAM
0005f000-00086fff : Reserved
```

```
00087000-00088fff : System RAM
00089000-00089fff : Reserved
0008a000-0008afff : System RAM
0008b000-000fffff : Reserved
  000a0000-000bffff : PCI Bus 0000:00
  000c0000-000cfdff : Video ROM
  000f0000-000fffff : System ROM
00100000-2b2fffff : System RAM
2b300000-2b300fff : Reserved
2b301000-2b338fff : System RAM
2b339000-2b339fff : Reserved
2b33a000-3b4c0017 : System RAM
3b4c0018-3b4ce057 : System RAM
3b4ce058-3b4cf017 : System RAM
3b4cf018-3b4df057 : System RAM
3b4df058-3b54bfff : System RAM
3b54c000-3b54cfff : ACPI Non-volatile Storage
```

```
# cat /proc/dma
 4: cascade
```

```
# ls /proc/ | grep -v "[0-9]" | tr '\n' ' '
acpi asound bootconfig buddyinfo bus cgroups cmdline consoles cpuinfo crypto
devices diskstats dma driver dynamic_debug execdomains fb filesystems fs
interrupts iomem ioports irq kallsyms kcore keys key-users kmsg kpagecgroup
kpagecount kpageflags latency_stats loadavg locks mdstat meminfo misc modules
mounts mtrr net pagetypeinfo partitions pressure sched_debug schedstat scsi self
slabinfo softirqs stat swaps sys sysrq-trigger sysvipc thread-self timer_list tty
uptime version vmallocinfo vmstat zoneinfo
```

```
# lsipc
RESOURCE DESCRIPTION                                              LIMIT   USED
USE%
MSGMNI   Number of message queues                                 32000      0
0.00%
MSGMAX   Max size of message (bytes)                               8192      -
-
MSGMNB   Default max size of queue (bytes)                        16384      -
-
SHMMNI   Shared memory segments                                    4096      9
0.22%
SHMALL   Shared memory pages                       18446744073692774399 132096
0.00%
SHMMAX   Max size of shared memory segment (bytes) 18446744073692774399      -
-
SHMMIN   Min size of shared memory segment (bytes)                    1      -
-
SEMMNI   Number of semaphore identifiers                          32000      0
0.00%
SEMMNS   Total number of semaphores                          1024000000      0
0.00%
SEMMSL   Max semaphores per semaphore set.                        32000      -
-
SEMOPM   Max number of operations per semop(2)                      500      -
-
SEMVMX   Semaphore max value                                      32767      -
-
```

```
# cat /proc/diskstats
 259       0 nvme0n1 103298 30626 6504888 23266 285345 265596 9330579 1489927 0 307238 1599210 0 0 0 0 31797
86016
 259       1 nvme0n1p1 230 197 13346 71 9 1 11 28 0 73 100 0 0 0 0 0 0
 259       2 nvme0n1p2 163 6 12690 39 3 0 24 2 0 68 42 0 0 0 0 0 0
 259       3 nvme0n1p3 102821 30423 6473484 23125 253536 265595 9330544 1403333 0 252484 1426459 0 0 0 0 0 0
 253       0 dm-0 109811 0 5767314 31998 224649 0 4523840 5719524 0 96771 5751522 0 0 0 0 0 0
 253       1 dm-1 111 0 4544 79 194 0 1552 18 0 53 97 0 0 0 0 0 0
 253       2 dm-2 23266 0 697546 11545 324927 0 4981448 539006 0 213858 550551 0 0 0 0 0 0
```

```
# cat /proc/interrupts
           CPU0       CPU1       CPU2       CPU3
   0:         11          0          0          0  IR-IO-APIC    2-edge      timer
   1:      43552          0          0       3905  IR-IO-APIC    1-edge      i8042
   8:          1          0          0          0  IR-IO-APIC    8-edge      rtc0
   9:        620       1870          0          0  IR-IO-APIC    9-fasteoi   acpi
  14:          0          0          0          0  IR-IO-APIC   14-fasteoi   INT3455:00
  16:      65446          0        281          0  IR-IO-APIC   16-fasteoi   i2c_designware.0, idma64.0,
i801_smbus
  20:          0          0          0          0  IR-IO-APIC   20-fasteoi   idma64.1
  55:       2749          0          0          0  IR-IO-APIC   55-fasteoi   ELAN0634:00
 120:          0          0          0          0  DMAR-MSI    0-edge      dmar0
 121:          0          0          0          0  DMAR-MSI    1-edge      dmar1
 122:          0          0          0          0  IR-PCI-MSI 475136-edge      PCIe PME
 123:          0          0          0          0  IR-PCI-MSI 479232-edge      PCIe PME
 124:          0          0          0          0  IR-PCI-MSI 483328-edge      PCIe PME
 125:          0          0          0          0  IR-PCI-MSI 376832-edge      ahci[0000:00:17.0]
 126:          0          0          0          0  IR-PCI-MSI 212992-edge      xhci_hcd
 127:     822194          0      78062          0  IR-PCI-MSI 327680-edge      xhci_hcd
 128:          0          0          0          0  IR-PCI-MSI 524288-edge      enp1s0
 129:          6          0          6          0  IR-PCI-MSI 1048576-edge      rtsx_pci
 130:          0         46          0          0  IR-PCI-MSI 360448-edge      mei_me
 131:          0          0          0       1628  IR-PCI-MSI 514048-edge      snd_hda_intel:card0
 132:          0         12          0          0  IR-PCI-MSI 1572864-edge      nvme0q0
 133:       2657          0          0          0  IR-PCI-MSI 1572865-edge      nvme0q1
 134:          0       2990          0          0  IR-PCI-MSI 1572866-edge      nvme0q2
 135:    4233412          0          0          0  IR-PCI-MSI 32768-edge      i915
 136:          0          0       2933          0  IR-PCI-MSI 1572867-edge      nvme0q3
 137:     273798          0          0          0  IR-PCI-MSI 333824-edge      iwlwifi: default queue
 138:      56411          0          0          0  IR-PCI-MSI 333825-edge      iwlwifi: queue 1
 139:      34218       6106          0          0  IR-PCI-MSI 333826-edge      iwlwifi: queue 2
 140:      56967          0       4519          0  IR-PCI-MSI 333827-edge      iwlwifi: queue 3
 141:      50959          0          0       3345  IR-PCI-MSI 333828-edge      iwlwifi: queue 4
 142:          9          6          0          0  IR-PCI-MSI 333829-edge      iwlwifi: exception
 143:          0          0          0       3027  IR-PCI-MSI 1572868-edge      nvme0q4
 NMI:         37        372        389        366   Non-maskable interrupts
 LOC:   10156520    8734224    8710150    8599818   Local timer interrupts
 SPU:          0          0          0          0   Spurious interrupts
 PMI:         37        372        389        366   Performance monitoring interrupts
 IWI:    2391895      58951      58554      61553   IRQ work interrupts
 RTR:          6          0          0          0   APIC ICR read retries
 RES:     361476     340578     331753     335200   Rescheduling interrupts
 CAL:    1024681    1010805     946474     862190   Function call interrupts
 TLB:    1027676    1078426    1143026    1102163   TLB shootdowns
 TRM:          0          0          0          0   Thermal event interrupts
 THR:          0          0          0          0   Threshold APIC interrupts
 DFR:          0          0          0          0   Deferred Error APIC interrupts
 MCE:          0          0          0          0   Machine check exceptions
 MCP:         95         95         95         95   Machine check polls
 ERR:          0
 MIS:          0
 PIN:          0          0          0          0   Posted-interrupt notification event
 NPI:          0          0          0          0   Nested posted-interrupt event
 PIW:          0          0          0          0   Posted-interrupt wakeup event
```

```
# lshw
H/W path            Device          Class          Description
=============================================================
                                    system         20SL
(LENOVO_MT_20SL_BU_idea_FM_Thinkbook 14-IIL)
/0                                  bus            LNVNB161216
/0/2                                memory         8GiB System Memory
/0/2/0                              memory         8GiB SODIMM DDR4 Synchronous
3200 MHz (0.3 ns)
/0/2/1                              memory         [empty]
/0/b                                memory         96KiB L1 cache
/0/c                                memory         64KiB L1 cache
/0/d                                memory         1MiB L2 cache
/0/e                                memory         4MiB L3 cache
/0/f                                processor      Intel(R) Core(TM) i3-1005G1 CPU
@ 1.20GHz
/0/10                               memory         1MiB BIOS
/0/100                              bridge         Intel Corporation
/0/100/2                            display        Iris Plus Graphics G1 (Ice
Lake)
/0/100/4                            generic        Intel Corporation
/0/100/d                            bus            Ice Lake Thunderbolt 3 USB
Controller
/0/100/d/0          usb1            bus            xHCI Host Controller
/0/100/d/1          usb2            bus            xHCI Host Controller
/0/100/14                           bus            Ice Lake-LP USB 3.1 xHCI Host
Controller
/0/100/14/0         usb3            bus            xHCI Host Controller
/0/100/14/0/4                       input          Optical USB Mouse
/0/100/14/0/5                       generic        ELAN:Fingerprint
```

```
/0/100/14/0/6                       multimedia     Integrated Camera
/0/100/14/1        usb4             bus            xHCI Host Controller
```

```
# hwinfo --short
cpu:
                        Intel(R) Core(TM) i3-1005G1 CPU @ 1.20GHz, 1115 MHz
                        Intel(R) Core(TM) i3-1005G1 CPU @ 1.20GHz, 1200 MHz
                        Intel(R) Core(TM) i3-1005G1 CPU @ 1.20GHz, 1200 MHz
                        Intel(R) Core(TM) i3-1005G1 CPU @ 1.20GHz, 1200 MHz
keyboard:
  /dev/input/event3     AT Translated Set 2 keyboard
mouse:
  /dev/input/mice       Logitech Optical Wheel Mouse
  /dev/input/mice       Elan Touchpad
monitor:
                        LG Display LCD Monitor
graphics card:
                        Intel VGA compatible controller
sound:
                        Intel Audio device
storage:
                        Samsung Electronics Non-Volatile memory controller
                        Intel Ice Lake-LP SATA Controller [AHCI mode]
network:
  wlp0s20f3             Intel WLAN controller
  enp1s0                Realtek RTL8111/8168/8411 PCI Express Gigabit Ethernet
Controller
network interface:
  enp1s0                Ethernet network interface
  wlp0s20f3             Ethernet network interface
```

```
# hwinfo --bios | head -n20
01: None 00.0: 10105 BIOS
  [Created at bios.186]
  Unique ID: rdCR.1ZF+r4EgHp4
  Hardware Class: bios
  BIOS Keyboard LED Status:
    Scroll Lock: off
    Num Lock: off
    Caps Lock: off
  Base Memory: 632 kB
  PnP BIOS: @@@0000
  BIOS32 Service Directory Entry: 0xfd000
  SMBIOS Version: 3.1
  Type 222 Record: #0
    Data 00: de 0e 00 00 01 99 00 03 10 01 20 02 30 03
    String 1: "Memory Init Complete"
    String 2: "End of DXE Phase"
    String 3: "BIOS Boot Complete"
  Group Associations: #1
    Group Name: "Intel(R) Silicon View Technology"
    Items: #0
```

```
# hwinfo --help
Usage: hwinfo [OPTIONS]
Probe for hardware.
Options:
    --<HARDWARE_ITEM>
        This option can be given more than once. Probe for a particular
        HARDWARE_ITEM. Available hardware items are:
        all, arch, bios, block, bluetooth, braille, bridge, camera,
        cdrom, chipcard, cpu, disk, dsl, dvb, fingerprint, floppy,
        framebuffer, gfxcard, hub, ide, isapnp, isdn, joystick, keyboard,
        memory, mmc-ctrl, modem, monitor, mouse, netcard, network, partition,
        pci, pcmcia, pcmcia-ctrl, pppoe, printer, redasd,
        reallyall, scanner, scsi, smp, sound, storage-ctrl, sys, tape,
        tv, uml, usb, usb-ctrl, vbe, wlan, xen, zip
```

```
# hwinfo --cpu | head -n 20
01: None 00.0: 10103 CPU
  [Created at cpu.462]
  Unique ID: rdCR.j8NaKXDZtZ6
  Hardware Class: cpu
  Arch: X86-64
  Vendor: "GenuineIntel"
  Model: 6.126.5 "Intel(R) Core(TM) i3-1005G1 CPU @ 1.20GHz"
  Features:
fpu,vme,de,pse,tsc,msr,pae,mce,cx8,apic,sep,mtrr,pge,mca,cmov,pat,pse36,clflush,d
ts,acpi,mmx,fxsr,sse,sse2,ss,ht,tm,pbe,syscall,nx,pdpe1gb,rdtscp,lm,constant_tsc,
art,arch_perfmon,pebs,bts,rep_good,nopl,xtopology,nonstop_tsc,cpuid,aperfmperf,ts
c_known_freq,pni,pclmulqdq,dtes64,monitor,ds_cpl,vmx,est,tm2,ssse3,sdbg,fma,cx16,
xtpr,pdcm,pcid,sse4_1,sse4_2,x2apic,movbe,popcnt,tsc_deadline_timer,aes,xsave,avx
,f16c,rdrand,lahf_lm,abm,3dnowprefetch,cpuid_fault,epb,invpcid_single,ssbd,ibrs,i
bpb,stibp,ibrs_enhanced,tpr_shadow,vnmi,flexpriority,ept,vpid,ept_ad,fsgsbase,tsc
_adjust,sgx,bmi1,avx2,smep,bmi2,erms,invpcid,avx512f,avx512dq,rdseed,adx,smap,avx
512ifma,clflushopt,intel_pt,avx512cd,sha_ni,avx512bw,avx512vl,xsaveopt,xsavec,xge
tbv1,xsaves,split_lock_detect,dtherm,ida,arat,pln,pts,hwp,hwp_notify,hwp_act_wind
ow,hwp_epp,hwp_pkg_req,avx512vbmi,umip,pku,ospke,avx512_vbmi2,gfni,vaes,vpclmulqd
q,avx512_vnni,avx512_bitalg,avx512_vpopcntdq,rdpid,sgx_lc,fsrm,md_clear,flush_l1d
,arch_capabilities
  Clock: 2395 MHz
  BogoMips: 2380.80
  Cache: 4096 kb
  Units/Processor: 16
  Config Status: cfg=new, avail=yes, need=no, active=unknown

02: None 01.0: 10103 CPU
  [Created at cpu.462]
  Unique ID: wkFv.j8NaKXDZtZ6
  Hardware Class: cpu
  Arch: X86-64
  Vendor: "GenuineIntel"
```

```
# hwinfo --wlan
07: PCI 14.3: 0282 WLAN controller
  [Created at pci.386]
  Unique ID: Dhtl.yW6fZKhWXd8
  SysFS ID: /devices/pci0000:00/0000:00:14.3
  SysFS BusID: 0000:00:14.3
  Hardware Class: network
  Model: "Intel WLAN controller"
  Vendor: pci 0x8086 "Intel Corporation"
  Device: pci 0x34f0
  SubVendor: pci 0x8086 "Intel Corporation"
  SubDevice: pci 0x0074
  Revision: 0x30
  Driver: "iwlwifi"
  Driver Modules: "iwlwifi"
  Device File: wlp0s20f3
  Features: WLAN
  Memory Range: 0x81430000-0x81433fff (rw,non-prefetchable)
  IRQ: 16 (no events)
  HW Address: 84:1b:77:00:78:c8
  Permanent HW Address: 84:1b:77:00:78:c8
  Link detected: yes
  WLAN channels: 1 2 3 4 5 6 7 8 9 10 11 12 13 36 40 44 48 52 56 60 64 100 104
108 112 116 120 124 128 132 136 140
  WLAN frequencies: 2.412 2.417 2.422 2.427 2.432 2.437 2.442 2.447 2.452 2.457
2.462 2.467 2.472 5.18 5.2 5.22 5.24 5.26 5.28 5.3 5.32 5.5 5.52 5.54 5.56 5.58
5.6 5.62 5.64 5.66 5.68 5.7
  WLAN encryption modes: WEP40 WEP104 TKIP CCMP
  WLAN authentication modes: open sharedkey wpa-psk wpa-eap
  Module Alias: "pci:v00008086d000034F0sv00008086sd00000074bc02sc80i00"
  Driver Info #0:
    Driver Status: iwlwifi is active
    Driver Activation Cmd: "modprobe iwlwifi"
  Config Status: cfg=new, avail=yes, need=no, active=unknown
```

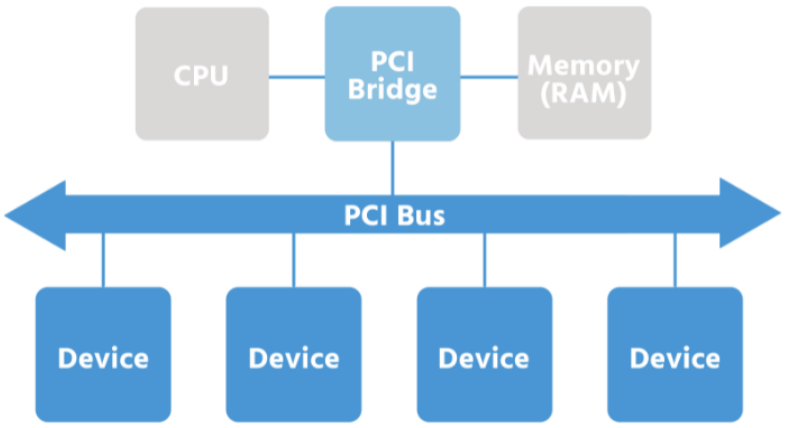
Hardware / Plug & Play Devices

Historically, a peripheral was added to the system by inserting a card on the peripherals bus, such as a video card or networking card (nowadays usually integrated in the motherboard). We can differentiate in PCI and USB devices.

It is important to know if a peripheral requires that the power to the computer system be turned off at the time it is connected (*coldplug*), or if the peripheral may be connected while the computer system is on (*hotplug*).

Modern computers typically use the Peripheral Component Interconnect Express (PCIe) bus to connect components inside the computer. For example, video, sound, network, and disk controllers are normally found on the PCIe bus.

Buses can be alternatively grouped into internal and external bus types. Internal buses are considered to be inside the actual computer, while external or “expansion” buses are used to attach external devices to the computer. Good examples of internal buses are the aforementioned PCIe bus, the older Industry Standard Architecture (ISA) bus, and the very popular Small Computer Systems Interface (SCSI) bus. An example of an external or expansion bus type would be the most universally available Universal Serial Bus (USB) bus.



lspci

Shows all devices currently connected to the PCI (Peripheral Component Interconnect) bus. PCI devices can be either a component attached to the motherboard, like a disk controller, or an expansion card fitted into a PCI slot, like an external graphics card.

lsusb

Lists USB (Universal Serial Bus) devices currently connected to the machine. Although USB devices for almost any imaginable purpose exist, the USB interface is largely used to connect input devices — keyboards, pointing devices — and removable storage media.

Commands:

- lspci
- lsusb
- usb-devices
- lspci -v
- lspci -v -s 003:002 [-k]
- lsusb -v -d 046d:c016

```
$lspci
00:00.0 Host bridge: Intel Corporation Device 8a02 (rev 03)
00:02.0 VGA compatible controller: Intel Corporation Iris Plus Graphics G1 (Ice Lake) (rev 07)
00:04.0 Signal processing controller: Intel Corporation Device 8a03 (rev 03)
00:0d.0 USB controller: Intel Corporation Ice Lake Thunderbolt 3 USB Controller (rev 03)
00:14.0 USB controller: Intel Corporation Ice Lake-LP USB 3.1 xHCI Host Controller (rev 30)
00:14.2 RAM memory: Intel Corporation Ice Lake-LP DRAM Controller (rev 30)
00:14.3 Network controller: Intel Corporation Killer Wi-Fi 6 AX1650i 160MHz Wireless Network Adapter (201NGW)
(rev 30)
00:15.0 Serial bus controller [0c80]: Intel Corporation Ice Lake-LP Serial IO I2C Controller #0 (rev 30)
00:16.0 Communication controller: Intel Corporation Ice Lake-LP Management Engine (rev 30)
00:17.0 SATA controller: Intel Corporation Ice Lake-LP SATA Controller [AHCI mode] (rev 30)
00:1d.0 PCI bridge: Intel Corporation Ice Lake-LP PCI Express Root Port #9 (rev 30)
00:1d.2 PCI bridge: Intel Corporation Device 34b2 (rev 30)
00:1d.4 PCI bridge: Intel Corporation Device 34b4 (rev 30)
00:1e.0 Communication controller: Intel Corporation Ice Lake-LP Serial IO UART Controller #0 (rev 30)
00:1f.0 ISA bridge: Intel Corporation Ice Lake-LP LPC Controller (rev 30)
00:1f.3 Audio device: Intel Corporation Ice Lake-LP Smart Sound Technology Audio Controller (rev 30)
00:1f.4 SMBus: Intel Corporation Ice Lake-LP SMBus Controller (rev 30)
00:1f.5 Serial bus controller [0c80]: Intel Corporation Ice Lake-LP SPI Controller (rev 30)
01:00.0 Ethernet controller: Realtek Semiconductor Co., Ltd. RTL8111/8168/8411 PCI Express Gigabit Ethernet
Controller (rev 15)
02:00.0 Unassigned class [ff00]: Realtek Semiconductor Co., Ltd. RTS522A PCI Express Card Reader (rev 01)
03:00.0 Non-Volatile memory controller: Samsung Electronics Co Ltd Device a809
```

```
# lspci -s 00:1f.3 -k
00:1f.3 Audio device: Intel Corporation Ice Lake-LP Smart Sound Technology Audio
Controller (rev 30)
        Subsystem: Lenovo Device 3852
        Kernel driver in use: snd_hda_intel
        Kernel modules: snd_hda_intel, snd_sof_pci
```

```
$lsusb
Bus 004 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub
Bus 003 Device 004: ID 04f2:b6d9 Chicony Electronics Co., Ltd Integrated Camera
Bus 003 Device 003: ID 04f3:0c4b Elan Microelectronics Corp. ELAN:Fingerprint
Bus 003 Device 002: ID 046d:c016 Logitech, Inc. Optical Wheel Mouse
Bus 003 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
Bus 002 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub
Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
```

```
# lsusb -t
/:  Bus 04.Port 1: Dev 1, Class=root_hub, Driver=xhci_hcd/6p, 10000M
/:  Bus 03.Port 1: Dev 1, Class=root_hub, Driver=xhci_hcd/12p, 480M
    |__ Port 4: Dev 6, If 0, Class=Human Interface Device, Driver=usbhid, 1.5M
    |__ Port 5: Dev 3, If 0, Class=Vendor Specific Class, Driver=, 12M
    |__ Port 6: Dev 4, If 0, Class=Video, Driver=uvcvideo, 480M
    |__ Port 6: Dev 4, If 1, Class=Video, Driver=uvcvideo, 480M
/:  Bus 02.Port 1: Dev 1, Class=root_hub, Driver=xhci_hcd/4p, 10000M
/:  Bus 01.Port 1: Dev 1, Class=root_hub, Driver=xhci_hcd/1p, 480M
```

```
$usb-devices

T:  Bus=01 Lev=00 Prnt=00 Port=00 Cnt=00 Dev#=  1 Spd=480 MxCh= 1
D:  Ver= 2.00 Cls=09(hub  ) Sub=00 Prot=01 MxPS=64 #Cfgs=  1
P:  Vendor=1d6b ProdID=0002 Rev=05.11
S:  Manufacturer=Linux 5.11.22-100.fc32.x86_64 xhci-hcd
S:  Product=xHCI Host Controller
S:  SerialNumber=0000:00:0d.0
C:  #Ifs= 1 Cfg#= 1 Atr=e0 MxPwr=0mA
I:  If#=0x0 Alt= 0 #EPs= 1 Cls=09(hub  ) Sub=00 Prot=00 Driver=hub
```

```
T:  Bus=02 Lev=00 Prnt=00 Port=00 Cnt=00 Dev#=  1 Spd=10000 MxCh= 4
D:  Ver= 3.10 Cls=09(hub  ) Sub=00 Prot=03 MxPS= 9 #Cfgs=  1
P:  Vendor=1d6b ProdID=0003 Rev=05.11
S:  Manufacturer=Linux 5.11.22-100.fc32.x86_64 xhci-hcd
S:  Product=xHCI Host Controller
S:  SerialNumber=0000:00:0d.0
C:  #Ifs= 1 Cfg#= 1 Atr=e0 MxPwr=0mA
I:  If#=0x0 Alt= 0 #EPs= 1 Cls=09(hub  ) Sub=00 Prot=00 Driver=hub

T:  Bus=03 Lev=00 Prnt=00 Port=00 Cnt=00 Dev#=  1 Spd=480 MxCh=12
D:  Ver= 2.00 Cls=09(hub  ) Sub=00 Prot=01 MxPS=64 #Cfgs=  1
P:  Vendor=1d6b ProdID=0002 Rev=05.11
S:  Manufacturer=Linux 5.11.22-100.fc32.x86_64 xhci-hcd
S:  Product=xHCI Host Controller
S:  SerialNumber=0000:00:14.0
C:  #Ifs= 1 Cfg#= 1 Atr=e0 MxPwr=0mA
I:  If#=0x0 Alt= 0 #EPs= 1 Cls=09(hub  ) Sub=00 Prot=00 Driver=hub

T:  Bus=03 Lev=01 Prnt=01 Port=03 Cnt=01 Dev#=  2 Spd=1.5 MxCh= 0
D:  Ver= 2.00 Cls=00(>ifc ) Sub=00 Prot=00 MxPS= 8 #Cfgs=  1
P:  Vendor=046d ProdID=c016 Rev=03.40
S:  Manufacturer=Logitech
S:  Product=Optical USB Mouse
C:  #Ifs= 1 Cfg#= 1 Atr=a0 MxPwr=100mA
I:  If#=0x0 Alt= 0 #EPs= 1 Cls=03(HID  ) Sub=01 Prot=02 Driver=usbhid

T:  Bus=03 Lev=01 Prnt=01 Port=04 Cnt=02 Dev#=  3 Spd=12  MxCh= 0
D:  Ver= 2.00 Cls=00(>ifc ) Sub=00 Prot=00 MxPS=64 #Cfgs=  1
P:  Vendor=04f3 ProdID=0c4b Rev=01.74
S:  Manufacturer=ELAN
S:  Product=ELAN:Fingerprint
C:  #Ifs= 1 Cfg#= 1 Atr=a0 MxPwr=100mA
I:  If#=0x0 Alt= 0 #EPs= 5 Cls=ff(vend.) Sub=00 Prot=00 Driver=(none)

T:  Bus=03 Lev=01 Prnt=01 Port=05 Cnt=03 Dev#=  4 Spd=480 MxCh= 0
D:  Ver= 2.01 Cls=ef(misc ) Sub=02 Prot=01 MxPS=64 #Cfgs=  1
P:  Vendor=04f2 ProdID=b6d9 Rev=26.99
S:  Manufacturer=Chicony Electronics Co.,Ltd.
S:  Product=Integrated Camera
S:  SerialNumber=0001
C:  #Ifs= 2 Cfg#= 1 Atr=80 MxPwr=500mA
I:  If#=0x0 Alt= 0 #EPs= 1 Cls=0e(video) Sub=01 Prot=00 Driver=uvcvideo
I:  If#=0x1 Alt= 0 #EPs= 0 Cls=0e(video) Sub=02 Prot=00 Driver=uvcvideo

T:  Bus=04 Lev=00 Prnt=00 Port=00 Cnt=00 Dev#=  1 Spd=10000 MxCh= 6
D:  Ver= 3.10 Cls=09(hub  ) Sub=00 Prot=03 MxPS= 9 #Cfgs=  1
P:  Vendor=1d6b ProdID=0003 Rev=05.11
S:  Manufacturer=Linux 5.11.22-100.fc32.x86_64 xhci-hcd
S:  Product=xHCI Host Controller
S:  SerialNumber=0000:00:14.0
C:  #Ifs= 1 Cfg#= 1 Atr=e0 MxPwr=0mA
I:  If#=0x0 Alt= 0 #EPs= 1 Cls=09(hub  ) Sub=00 Prot=00 Driver=hub
```

```
$lspci -v
00:00.0 Host bridge: Intel Corporation Device 8a02 (rev 03)
       Subsystem: Lenovo Device 3852
       Flags: bus master, fast devsel, latency 0
       Capabilities: <access denied>
       Kernel driver in use: icl_uncore

00:02.0 VGA compatible controller: Intel Corporation Iris Plus Graphics G1 (Ice
Lake) (rev 07) (prog-if 00 [VGA controller])
       DeviceName: To Be Filled by O.E.M.
       Subsystem: Lenovo Device 3852
       Flags: bus master, fast devsel, latency 0, IRQ 135
       Memory at 80000000 (64-bit, non-prefetchable) [size=16M]
       Memory at 70000000 (64-bit, prefetchable) [size=256M]
       I/O ports at 3000 [size=64]
       Expansion ROM at 000c0000 [virtual] [disabled] [size=128K]
       Capabilities: <access denied>
       Kernel driver in use: i915
       Kernel modules: i915
```

```
00:04.0 Signal processing controller: Intel Corporation Device 8a03 (rev 03)
        Subsystem: Lenovo Device 3852
        Flags: fast devsel, IRQ 16
        Memory at 81400000 (64-bit, non-prefetchable) [size=64K]
        Capabilities: <access denied>
        Kernel driver in use: proc_thermal
        Kernel modules: processor_thermal_device
```

```
# lsusb -v
Bus 004 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub
Device Descriptor:
  bLength                18
  bDescriptorType         1
  bcdUSB               3.10
  bDeviceClass            9 Hub
  bDeviceSubClass         0
  bDeviceProtocol         3
  bMaxPacketSize0         9
  idVendor           0x1d6b Linux Foundation
  idProduct          0x0003 3.0 root hub
  bcdDevice            5.11
  iManufacturer           3 Linux 5.11.22-100.fc32.x86_64 xhci-hcd
  iProduct                2 xHCI Host Controller
  iSerial                 1 0000:00:14.0
  bNumConfigurations      1
  Configuration Descriptor:
    bLength                 9
    bDescriptorType         2
    wTotalLength       0x001f
    bNumInterfaces          1
    bConfigurationValue     1
    iConfiguration          0
    bmAttributes         0xe0
```

```
$lspci -v -s 00:02
00:02.0 VGA compatible controller: Intel Corporation Iris Plus Graphics G1 (Ice
Lake) (rev 07) (prog-if 00 [VGA controller])
        DeviceName: To Be Filled by O.E.M.
        Subsystem: Lenovo Device 3852
        Flags: bus master, fast devsel, latency 0, IRQ 135
        Memory at 80000000 (64-bit, non-prefetchable) [size=16M]
        Memory at 70000000 (64-bit, prefetchable) [size=256M]
        I/O ports at 3000 [size=64]
        Expansion ROM at 000c0000 [virtual] [disabled] [size=128K]
        Capabilities: <access denied>
        Kernel driver in use: i915
        Kernel modules: i915
```

```
$lsusb -v -d 046d:c016
Bus 003 Device 002: ID 046d:c016 Logitech, Inc. Optical Wheel Mouse
Couldn't open device, some information will be missing
Device Descriptor:
  bLength                18
  bDescriptorType         1
  bcdUSB               2.00
  bDeviceClass            0
  bDeviceSubClass         0
  bDeviceProtocol         0
  bMaxPacketSize0         8
  idVendor           0x046d Logitech, Inc.
  idProduct          0xc016 Optical Wheel Mouse
  bcdDevice            3.40
  iManufacturer           1
  iProduct                2
  iSerial                 0
  bNumConfigurations      1
  Configuration Descriptor:
    bLength                 9
    bDescriptorType         2
```

```
    wTotalLength       0x0022
    bNumInterfaces          1
    bConfigurationValue     1
    iConfiguration          0
    bmAttributes         0xa0
      (Bus Powered)
      Remote Wakeup
    MaxPower              100mA
    Interface Descriptor:
      bLength                 9
      bDescriptorType         4
      bInterfaceNumber        0
      bAlternateSetting       0
      bNumEndpoints           1
      bInterfaceClass         3 Human Interface Device
      bInterfaceSubClass      1 Boot Interface Subclass
      bInterfaceProtocol      2 Mouse
      iInterface              0
        HID Device Descriptor:
          bLength                 9
          bDescriptorType        33
          bcdHID               1.10
          bCountryCode            0 Not supported
          bNumDescriptors         1
          bDescriptorType        34 Report
          wDescriptorLength      52
         Report Descriptors:
           ** UNAVAILABLE **
      Endpoint Descriptor:
        bLength                 7
        bDescriptorType         5
        bEndpointAddress     0x81  EP 1 IN
        bmAttributes            3
          Transfer Type            Interrupt
          Synch Type               None
          Usage Type               Data
        wMaxPacketSize     0x0004  1x 4 bytes
        bInterval              10
```

Hardware subsystem

The trio of device management tools starts with udev, a device management subsystem that manages the /dev directory and will automatically create and destroy node points (references to a device) for devices that are attached to the system, or subsequently removed.

To accomplish this, the ***udev*** subsystem maintains a pseudo-filesystem mounted as the /dev directory. The files in the /dev directory represent devices currently connected to the system. When the Linux kernel detects a device being connected, the udev daemon is used to create a device file (or node) in the /dev directory. If the device is removed, the udev daemon then removes the device node in the /dev directory.

Configuration files in the /etc/udev/rules.d directory are used to define rules that assign specific ownerships, permissions, and persistent names to these device files. These files allow a user to configure how udev handles the devices it manages.

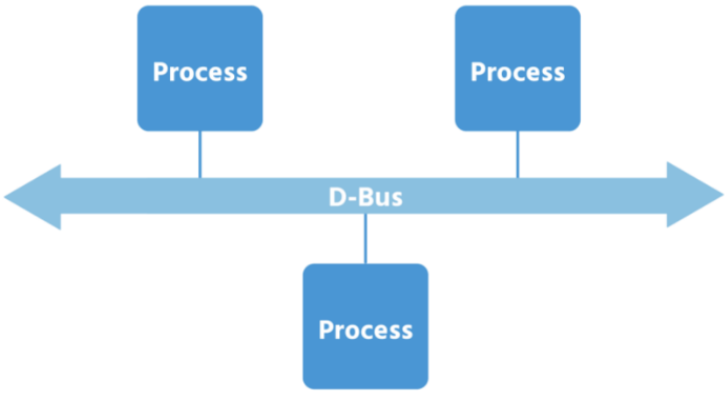
The second part of the device management trio is the ***sysfs*** subsystem (typically mounted as the /sys subdirectory), which is another in-memory filesystem that consists of directories and text files that contain values about the kernel's operation and configuration.

Modern systems (kernels 2.5 and beyond) use sysfs to express kernel information into the /sys directory because the procfs subsystem (and the /proc directory) had become increasingly busy and cluttered.

Finally, the last of the trinity of device management tools is the Hardware Abstraction Layer (***HAL***) daemon. As the kernel detects a device, it puts the information about the device into the appropriate files in the /sys directory. The hald is responsible for discovering and maintaining a list of connected devices and their attributes by monitoring the files in the /sys directory.

Finally, when programs want information about devices, they are able to query hald by using D-Bus. ***D-Bus*** is a method of allowing inter-process communications, primarily the communications between components in the Linux Desktop environments, KDE and GNOME. D-Bus is a software bus that allows individual and groups of processes to communicate on a single virtual bus or channel, a feature called Interprocess Communication (IPC).

The ***/sys*** directory has the specific purpose of storing device information and kernel data related to hardware, whilst ***/proc*** also contains information about various kernel data structures, including running processes and configuration.



Programs can also register themselves with D-bus to receive notifications from hald when specific types of hardware events occur. When the state of a hardware device changes, hald uses D-Bus to send notifications to those programs that have been registered for that type of hardware event.

The job of udev is to let your computer know of device events, udev can manage any device that shows a link in the /dev directory when attached to the system, which udev is able to do through scripts known most commonly as udev rules. Udev can detect when a device has been attached or removed. Udev rules can establish custom actions that are taken when these events occur.

Commands:

- ls /proc

- ls /sys
- tree /proc
- tree /sys
- /etc/udev/rules.d
- /usr/lib/udev/rules.d
- udevadm monitor
- udevadm info /dev/sda

- <deprecated> lshal
- <deprecated> lshal | grep

```
# tree -d /proc/ | head -n20
/proc/
├── 1
│   ├── attr
│   ├── cwd -> /
│   ├── fd
│   │   └── 7 -> /sys/fs/cgroup
│   ├── fdinfo
│   ├── map_files
│   ├── net
│   │   ├── dev_snmp6
│   │   ├── netfilter
│   │   ├── rpc
│   │   │   ├── auth.unix.gid
│   │   │   └── auth.unix.ip
│   │   └── stat
│   ├── ns
│   ├── root -> /
│   └── task
│       └── 1
│           ├── attr
```

```
$tree -d /sys | head -n15
/sys
├── block
│   ├── dm-0 -> ../devices/virtual/block/dm-0
│   ├── dm-1 -> ../devices/virtual/block/dm-1
│   ├── dm-2 -> ../devices/virtual/block/dm-2
│   └── nvme0n1 ->
../devices/pci0000:00/0000:00:1d.4/0000:03:00.0/nvme/nvme0/nvme0n1
├── bus
│   ├── ac97
│   │   ├── devices
│   │   └── drivers
│   ├── acpi
│   │   ├── devices
│   │   │   ├── ACPI0003:00 ->
../../../devices/LNXSYSTM:00/LNXSYBUS:00/ACPI0003:00
│   │   │   ├── ACPI000C:00 ->
../../../devices/LNXSYSTM:00/LNXSYBUS:00/ACPI000C:00
│   │   │   ├── ACPI000E:00 ->
../../../devices/LNXSYSTM:00/LNXSYBUS:00/ACPI000E:00
```

```
# tree /etc/udev/
/etc/udev/
├── hwdb.bin
├── hwdb.d
├── rules.d
│   └── 70-persistent-ipoib.rules
└── udev.conf
```

```
# mount -t sysfs,proc
```

```
sysfs on /sys type sysfs (rw,nosuid,nodev,noexec,relatime,seclabel)
proc on /proc type proc (rw,nosuid,nodev,noexec,relatime)
```

```
## monitorar desconnectar el mouse (per exemple)

# udevadm monitor
monitor will print the received events for:
UDEV - the event which udev sends out after rule processing
KERNEL - the kernel uevent
KERNEL[26231.948187] remove
/devices/pci0000:00/0000:00:14.0/usb3/3-4/3-4:1.0/0003:046D:C016.0001/input/input4/mouse0 (input)
UDEV  [26231.952813] remove
/devices/pci0000:00/0000:00:14.0/usb3/3-4/3-4:1.0/0003:046D:C016.0001/input/input4/mouse0 (input)
KERNEL[26231.953839] remove
/devices/pci0000:00/0000:00:14.0/usb3/3-4/3-4:1.0/0003:046D:C016.0001/input/input4/event4 (input)
UDEV  [26231.954675] remove
/devices/pci0000:00/0000:00:14.0/usb3/3-4/3-4:1.0/0003:046D:C016.0001/input/input4/event4 (input)
KERNEL[26231.958873] remove   /devices/pci0000:00/0000:00:14.0/usb3/3-4/3-4:1.0/0003:046D:C016.0001/input/input4
(input)
KERNEL[26231.959183] remove
/devices/pci0000:00/0000:00:14.0/usb3/3-4/3-4:1.0/0003:046D:C016.0001/hidraw/hidraw0 (hidraw)
KERNEL[26231.959210] unbind   /devices/pci0000:00/0000:00:14.0/usb3/3-4/3-4:1.0/0003:046D:C016.0001 (hid)
KERNEL[26231.959246] remove   /devices/pci0000:00/0000:00:14.0/usb3/3-4/3-4:1.0/0003:046D:C016.0001 (hid)
KERNEL[26231.959267] unbind   /devices/pci0000:00/0000:00:14.0/usb3/3-4/3-4:1.0 (usb)
KERNEL[26231.959290] remove   /devices/pci0000:00/0000:00:14.0/usb3/3-4/3-4:1.0 (usb)
```

```
# monitorar inserir un pen USB

# udevadm monitor
monitor will print the received events for:
UDEV - the event which udev sends out after rule processing
KERNEL - the kernel uevent

KERNEL[26355.365704] add      /devices/pci0000:00/0000:00:14.0/usb4/4-1 (usb)
KERNEL[26355.366596] add      /devices/pci0000:00/0000:00:14.0/usb4/4-1/4-1:1.0
(usb)
KERNEL[26355.366705] bind     /devices/pci0000:00/0000:00:14.0/usb4/4-1 (usb)
UDEV  [26355.406578] add      /devices/pci0000:00/0000:00:14.0/usb4/4-1 (usb)
KERNEL[26355.415811] add      /devices/virtual/workqueue/scsi_tmf_2 (workqueue)
KERNEL[26355.416470] add
/devices/pci0000:00/0000:00:14.0/usb4/4-1/4-1:1.0/host2 (scsi)
KERNEL[26355.416529] add
/devices/pci0000:00/0000:00:14.0/usb4/4-1/4-1:1.0/host2/scsi_host/host2
(scsi_host)
KERNEL[26355.416549] bind     /devices/pci0000:00/0000:00:14.0/usb4/4-1/4-1:1.0
(usb)
KERNEL[26355.416560] add      /bus/usb/drivers/usb-storage (drivers)
```

```
# udevadm info /dev/nvme0n1p1
P: /devices/pci0000:00/0000:00:1d.4/0000:03:00.0/nvme/nvme0/nvme0n1/nvme0n1p1
N: nvme0n1p1
L: 0
S: disk/by-partlabel/EFI\x20System\x20Partition
S: disk/by-partuuid/e556663a-ed3f-4d5b-b69e-0abe9158c16b
S: disk/by-path/pci-0000:03:00.0-nvme-1-part1
S: disk/by-id/nvme-SAMSUNG_MZALQ256HAJD-000L2_S4ULNF2NB44121-part1
S: disk/by-id/nvme-eui.002538ab01d2bf96-part1
S: disk/by-uuid/7F70-2AC1
E:
DEVPATH=/devices/pci0000:00/0000:00:1d.4/0000:03:00.0/nvme/nvme0/nvme0n1/nvme0n1p
1
E: DEVNAME=/dev/nvme0n1p1
E: DEVTYPE=partition
E: PARTN=1
E: PARTNAME=EFI System Partition
E: MAJOR=259
E: MINOR=1
E: SUBSYSTEM=block
E: USEC_INITIALIZED=10646632
E: ID_SERIAL_SHORT=S4ULNF2NB44121
E: ID_WWN=eui.002538ab01d2bf96
```

```
E: ID_MODEL=SAMSUNG MZALQ256HAJD-000L2
E: ID_REVISION=AL2QFXV7
E: ID_SERIAL=SAMSUNG MZALQ256HAJD-000L2_S4ULNF2NB44121
E: ID_PATH=pci-0000:03:00.0-nvme-1
E: ID_PATH_TAG=pci-0000_03_00_0-nvme-1
E: ID_PART_TABLE_UUID=bfa8875e-2f5d-4504-812b-618cfd968ebd
E: ID_PART_TABLE_TYPE=gpt
E: ID_FS_UUID=7F70-2AC1
E: ID_FS_UUID_ENC=7F70-2AC1
E: ID_FS_VERSION=FAT16
E: ID_FS_TYPE=vfat
E: ID_FS_USAGE=filesystem
E: ID_PART_ENTRY_SCHEME=gpt
E: ID_PART_ENTRY_NAME=EFI\x20System\x20Partition
E: ID_PART_ENTRY_UUID=e556663a-ed3f-4d5b-b69e-0abe9158c16b
E: ID_PART_ENTRY_TYPE=c12a7328-f81f-11d2-ba4b-00a0c93ec93b
E: ID_PART_ENTRY_NUMBER=1
E: ID_PART_ENTRY_OFFSET=2048
E: ID_PART_ENTRY_SIZE=409600
E: ID_PART_ENTRY_DISK=259:0
E: UDISKS_IGNORE=1
E: DEVLINKS=/dev/disk/by-partlabel/EFI\x20System\x20Partition
/dev/disk/by-partuuid/e556663a-ed3f-4d5b-b69e-0abe9158c16b
/dev/disk/by-path/pci-0000:03:00.0-nvme-1-part1
/dev/disk/by-id/nvme-SAMSUNG_MZALQ256HAJD-000L2_S4ULNF2NB44121-part1
/dev/disk/by-id/nvme-eui.002538ab01d2bf96-part1 /dev/disk/by-uuid/7F70-2AC1
E: TAGS=:systemd:
```

```
# cat /etc/udev/rules.d/70-persistent-ipoib.rules
# This is a sample udev rules file that demonstrates how to get udev to
# set the name of IPoIB interfaces to whatever you wish.  There is a
# 16 character limit on network device names.
#
# Important items to note: ATTR{type}=="32" is IPoIB interfaces, and the
# ATTR{address} match must start with ?* and only reference the last 8
# bytes of the address or else the address might not match the variable QPN
# portion.
#
# Modern udev is case sensitive and all addresses need to be in lower case.
#
# ACTION=="add", SUBSYSTEM=="net", DRIVERS=="?*", ATTR{type}=="32",
ATTR{address}=="?*00:02:c9:03:00:31:78:f2", NAME="mlx4_ib3"
```

```
# ls /usr/lib/udev/rules.d/
01-md-raid-creating.rules             70-touchpad.rules
10-dm.rules                           70-uaccess.rules
11-dm-lvm.rules                       70-wacom.rules
11-dm-mpath.rules                     71-seat.rules
11-dm-parts.rules                     73-seat-late.rules
```

Kernel modules

Linux kernel may load software called kernel modules to support the device. Some devices are so common that the software to support them is normally compiled into the kernel itself, Other devices that are not as common will have modules that are only loaded if the device is detected.

Kernel modules can be used for more than supporting devices; since modules are simply software that is able to run within the kernel, they are able to be used for virtually anything. Some common uses besides device drivers include filesystems modules, networking protocols modules, and cryptographic algorithms modules.

- lsmod
- modinfo
- modprobe
- modprobe -r
- /etc/modprobe.d
- /etc/modprobe.d/blacklist

```
# lsmod | head -n15
Module                  Size  Used by
nls_utf8               16384  0
hfsplus               126976  0
uas                    32768  0
usb_storage            81920  1 uas
lp                     20480  0
parport_pc             40960  0
st                     65536  0
ppdev                  24576  0
parport                69632  3 parport_pc,lp,ppdev
binfmt_misc            24576  1
veth                   32768  0
rfcomm                 90112  0
nf_conntrack_netlink    53248  0
xt_addrtype            16384  2
```

```
# lsmod | grep vfat
vfat                   20480  1
fat                    81920  1 vfat

# lsmod | grep iptable
iptable_nat            16384  1
nf_nat                 49152  5
ip6table_nat,nf_nat_tftp,nft_chain_nat,iptable_nat,xt_MASQUERADE
iptable_mangle         16384  1
iptable_raw            16384  0
iptable_security       16384  0
iptable_filter         16384  1
ip_tables              28672  5
iptable_filter,iptable_security,iptable_raw,iptable_nat,iptable_mangle
```

```
# modinfo ext4
name:           ext4
filename:       (builtin)
softdep:        pre: crc32c
license:        GPL
file:           fs/ext4/ext4
description:    Fourth Extended Filesystem
author:         Remy Card, Stephen Tweedie, Andrew Morton, Andreas Dilger,
Theodore Ts'o and others
alias:          fs-ext4
alias:          ext3
alias:          fs-ext3
alias:          ext2
alias:          fs-ext2
```

```
# modinfo vfat
filename:       /lib/modules/5.11.22-100.fc32.x86_64/kernel/fs/fat/vfat.ko.xz
author:         Gordon Chaffee
description:    VFAT filesystem support
license:        GPL
alias:          fs-vfat
depends:        fat
retpoline:      Y
intree:         Y
name:           vfat
```

```
vermagic:       5.11.22-100.fc32.x86_64 SMP mod_unload
sig_id:         PKCS#7
signer:         Fedora kernel signing key
sig_key:        5B:27:E3:B7:61:D2:FB:F5:2C:B1:EF:06:ED:31:9A:25:06:A9:3F:7F
sig_hashalgo:   sha256
signature:      05:EA:60:71:6B:A0:32:8F:D8:E7:93:EC:10:DC:FE:26:E0:C6:9F:E3:
```

```
# lspci  -v -s 01:00.0
01:00.0 Ethernet controller: Realtek Semiconductor Co., Ltd. RTL8111/8168/8411
PCI Express Gigabit Ethernet Controller (rev 15)
        Subsystem: Lenovo Device 3852
        Flags: bus master, fast devsel, latency 0, IRQ 16
        I/O ports at 2000 [size=256]
        Memory at 81304000 (64-bit, non-prefetchable) [size=4K]
        Memory at 81300000 (64-bit, non-prefetchable) [size=16K]
        Capabilities: [40] Power Management version 3
        Capabilities: [50] MSI: Enable- Count=1/1 Maskable- 64bit+
        Capabilities: [70] Express Endpoint, MSI 01
        Capabilities: [b0] MSI-X: Enable+ Count=4 Masked-
        Capabilities: [100] Advanced Error Reporting
        Capabilities: [140] Virtual Channel
        Capabilities: [160] Device Serial Number 00-00-00-00-00-00-00-00
        Capabilities: [170] Latency Tolerance Reporting
        Capabilities: [178] L1 PM Substates
        Kernel driver in use: r8169
        Kernel modules: r8169
```

```
# modinfo r8169
filename:
/lib/modules/5.11.22-100.fc32.x86_64/kernel/drivers/net/ethernet/realtek/r8169.ko
.xz
firmware:       rtl_nic/rtl8125b-2.fw
firmware:       rtl_nic/rtl8125a-3.fw
...
softdep:        pre: realtek
description:    RealTek RTL-8169 Gigabit Ethernet driver
author:         Realtek and the Linux r8169 crew <netdev@vger.kernel.org>
alias:          pci:v000010ECd00003000sv*sd*bc*sc*i*
alias:          pci:v000010ECd00008125sv*sd*bc*sc*i*
...
name:           r8169
vermagic:       5.11.22-100.fc32.x86_64 SMP mod_unload
sig_id:         PKCS#7
signer:         Fedora kernel signing key
sig_key:        5B:27:E3:B7:61:D2:FB:F5:2C:B1:EF:06:ED:31:9A:25:06:A9:3F:7F
sig_hashalgo:   sha256
signature:      57:68:C9:7D:33:B6:26:E2:64:6E:37:86:E3:27:67:4F:76:77:B2:D3:
```

```
# locate r8169
/usr/lib/modules/5.11.11-100.fc32.x86_64/kernel/drivers/net/ethernet/realtek/r8169.ko.xz
/usr/lib/modules/5.11.16-100.fc32.x86_64/kernel/drivers/net/ethernet/realtek/r8169.ko.xz
/usr/lib/modules/5.11.22-100.fc32.x86_64/kernel/drivers/net/ethernet/realtek/r8169.ko.xz
/usr/src/kernels/5.11.11-100.fc32.x86_64/include/config/r8169.h
/usr/src/kernels/5.11.16-100.fc32.x86_64/include/config/r8169.h
/usr/src/kernels/5.11.22-100.fc32.x86_64/include/config/r8169.h
```

```
# modinfo -p snd_hda_intel
index:Index value for Intel HD audio interface. (array of int)
id:ID string for Intel HD audio interface. (array of charp)
enable:Enable Intel HD audio interface. (array of bool)
model:Use the given board model. (array of charp)
position_fix:DMA pointer read method.(-1 = system default, 0 = auto, 1 = LPIB, 2
= POSBUF, 3 = VIACOMBO, 4 = COMBO, 5 = SKL+, 6 = FIFO). (array of int)
bdl_pos_adj:BDL position adjustment offset. (array of int)
probe_mask:Bitmask to probe codecs (default = -1). (array of int)
probe_only:Only probing and no codec initialization. (array of int)
jackpoll_ms:Ms between polling for jack events (default = 0, using unsol events
only) (array of int)
single_cmd:Use single command to communicate with codecs (for debugging only).
(bint)
enable_msi:Enable Message Signaled Interrupt (MSI) (bint)
patch:Patch file for Intel HD audio interface. (array of charp)
```

```
beep_mode:Select HDA Beep registration mode (0=off, 1=on) (default=1). (array of
bool)
dmic_detect:Allow DSP driver selection (bypass this driver) (0=off, 1=on)
(default=1); deprecated, use snd-intel-dspcfg.dsp_driver option instead (bool)
power_save:Automatic power-saving timeout (in second, 0 = disable). (xint)
pm_blacklist:Enable power-management denylist (bool)
power_save_controller:Reset controller in power save mode. (bool)
align_buffer_size:Force buffer and period sizes to be multiple of 128 bytes.
(bint)
snoop:Enable/disable snooping (bint)
```

```
# modprobe <module>
```

```
# modprobe -r <module>
```

```
# ls /etc/modprobe.d/
firewalld-sysctls.conf  kvm.conf  lockd.conf  mlx4.conf  truescale.conf
```

Exercices

Exemples d'ordres

1. Monitoritzar els missatges de l'arrencada.
   - dmesg
   - dmesg | grep irq
   - dmesg | grep sd

2. Monitoritzar cpu, pci i usb.
   - lscpu
   - lspci
   - lscpi -tv
   - lscpi -vvv 3.2
   - lsmod
   - lsusb

3. Monitoritzar els dispositius via la capa d'abstracció HAL.
   - lshal
   - lshal -s
   - lshal | grep udi
   - lshal -u /org/freedesktop/Hal/devices/net_0a_00_27_00_00_00

4. Monitoritzar el hd.
   - # hdparm /dev/sda
   - # fdisk /dev/sda1

5. Observar l'estrucrura de fitxers dels dispositius.
   - less /proc/devices
   - less /proc/cpuinfo

- less /proc/iomem
- less /proc/ioports
- less /proc/interrupst (obtenir la llista estàndard d'interrupcions)
- less /proc/diskstats
- less /proc/dma $ telnet pc84

6. Identificar devices per ids diferents
   - tree /dev/disk
   - tree /dev
   - tree /sys
   - tree /sys/disk
   - tree /sys/bus

7. Identificar un device, les seves característiques i el seu driver (i el paquet)
   - # lspci -tv
   - # lspci -vvv 00:01
   - # lsmod | grep <nommòdul>
   - # lsinfo <nommòdul>
   - # locate <fitxer.ko>
   - # rpm -qpf <fitxer.ko>

Exercicis a fer

8. Identifica i recopila tota la informació del la targeta de vídeo:
   - informació pci o usb detallada.
   - Quina IRQ utilitza?.
   - Nom del driver.
   - Fitxer i paquet del driver.
   - Indica tots els noms (alias) del dispositiu (by-id, by-path, by-label, by-uuid, ...)
   - localitza el directori corresponent en cada cas.

9. Identifica i recopila tota la informació del la partició sda5:
   - informació pci o usb detallada.
   - Quina IRQ utilitza?.
   - Nom del driver.
   - Fitxer i paquet del driver.
   - Indica tots els noms (alias) del dispositiu (by-id, by-path, by-label, by-uuid, ...)
   - localitza el directori corresponent en cada cas.

10. Identifica i recopila tota la informació del mouse:
    - informació pci o usb detallada.
    - Quina IRQ utilitza?.
    - Nom del driver.
    - Fitxer i paquet del driver.
    - Indica tots els noms (alias) del dispositiu (by-id, by-path, by-label, by-uuid, ...)
    - localitza el directori corresponent en cada cas.

1. Uname. Identify all the components shown in `uname -a`
    a. Operating system
    b. Kernel release
    c. Kernel version
    d. Hostname
    e. Machine
    f. Processor
    g. hardware-platform

2. Uname. Execute the uname command to show :
    a. Operating system
    b. Kernel release
    c. Kernel version
    d. Hostname
    e. Machine
    f. Processor
    g. Hardware-platform

3. CPU. Identify the cpu characteristics:
    a. Architecture:
    b. Number of cpus
    c. Model name
    d. Virtualization

4. CPU.
    a. Show the known vulnerabilities of the cpu.
    b. Show the known bugs of the cpu.

5. CPU. Has the cpu the virtualizatio flags *vmx* or *svm*?

6. RAM. Check in Gi Bytes the mem:
    a. Total
    b. Used
    c. Free
    d. Buffers/cache
    e. Total Swap

7. RAM. Which file contains information about the RAM ?

8. Firmware. Using the command `dmidecode`:
    a. Show all the BIOS information.
    b. Show the BIOS vendor.

9. DISK. She the next disk characteristics:
    a. Show all partitions.
    b. Show the disk space usage.
    c. Show the UUID, LABELS (and more) of all partitions.
    d. Using the `tree` command show all the disk entries.

10. Hardware resources. Show:
    a. The ioports
    b. The interrupts
    c. The dma information.
    d. All the hardware information in short version.

11. Hardware resources.
    a. Which is the network card interrupt?
    b. Which is the sound card interrupt?

12. Hardware plug & play.
    a. List all pci devices
    b. List all usb devices
    c. Show detailed information of the mouse device.
    d. Show detailed information of the network card device.
    e. Show the sound device information including the kernel module name.
    f. Show the usb devices in a tree list.

13. Hardware subsystem.
    a. List de /proc directory.
    b. Show the tree schema of the /sys directory.
    c. Identify three files in the /proc directory.
    d. Show the /sys type of file system.

14. Hardware subsystem
    a. Activate monitoring udev rules.
    b. Unplug the mous.
    c. Plug the mouse.
    d. Plug an USB disk.
    e. Unplug the USB disk.

15. Kernel modules.
    a. List the kernel file.
    b. List the kernel module currently loaded.
    c. Show information about the sound kernel module.
    d. Show information about the network kernel module.
    e. Choose another device, locate the kernel module that uses and show its information.

16. Kernel modules.
    a. Load a kernel module.
    b. List the loaded kernel modules

c. Unload a kernel module.

---

17. Firmware. Respecte als dos sistemes BIOS/UEFI, quin dels dos sistemes té tota la seva informació gravada a una memòria a la placa mare quina té una part a una partició del disc dur?

18. Ara volem fer una instal·lació via xarxa utilitzant el protocol PXE a un ordinador que en principi no permet aquesta opció. Que hauríem de fer?

19. Si el firmware fa servir l'estàndard UEFI en comptes de l'estàndard BIOS, pot fer servir l'opció _*Secure Boot*_. Quina és la funcionalitat que ens proporciona Secure Boot? Escull una opció:
    a. Si aquesta opció està activada es fa un xequeig antivirus d'inici.
    b. Si aquesta opció està activada només es poden instal·lar productes Microsoft.
    c. Si aquesta opció està activada només es poden instal·lar binaris amb signatura.
    d. Cap de les anteriors és correcta (troba quina és)

20. Amb quina ordre podem veure els diferents connectors que tenim al nostre pc? O informació de la torre/caixa/carcassa?

21. Feu un cop d'ull al directori /proc:
    a. Que són els directoris *numèrics* que hi ha dintre de /proc?
    b. Llistar el contingut d'un d'aquests directoris *numèrics*.
    c. Observeu la mida de cada un d'aquests fitxers, es normal?
    d. Escolliu-ne un, per exemple *cmdline* i mireu el seu contingut

22. Veiem un exemple de com tunejar algun dels valors del sistema mitjançant /proc. Quan fem un ping a broadcast (i.e a tots les pc's de la nostra xarxa) per defecte el host no els retorna (per evitar atacs DoS). Això ho podem veure amb:
    `cat /proc/sys/net/ipv4/icmp_echo_ignore_broadcasts`
    a. Si volem que no els ignori, aquest fitxer hauria de contenir un 0, com ho faríem?
    b. Amb quina altra ordre es poden canviar aquests paràmetres?

23. Què conté el fitxer */sys/block/sda/size*?

24. A quin directori l'administrador pot definir regles propies d'udev?