

CS 447/647

Storage
Disk Management

Overview

- Hardware
- /sys files
- /dev files
- Partitioning
- **LVM**
- **mdraid**
- **drbd (light overview)**

References

Clausen, Andrew. "Parted User's Manual." *Parted User's Manual*, 2019, www.gnu.org/software/parted/manual/parted.html

.

Nemeth, Evi, et al. *UNIX and Linux System Administration Handbook*. Addison-Wesley, 2018.

Hardware

● Interfaces

- SATA - Consumer 6Gb/s
 - Consumer
- SAS - Enterprise 24Gb/s, i2c sideband interface
 - Higher Reliability, Higher Cost, 'Enterprise'
- **PCIe - NVMe, Speed**
- M.2 - Single connector for SATA+NVMe
- U.2 - Connector for 2.5" enterprise NVMe drives
- EDSFF - Latest form factor for enterprise NVMe drives
 - Connectors are E1 and E3
- Fiber Channel - Optical Fiber, 128Gb/s
 - Used in high-end network attached storage appliances (NetApp, Pure, etc.)

● Disk Type

- Hard Drive - Rotational 7,200RPMs
 - Rotational is prone to mechanical failure
- Solid-State Disk - NAND Flash Memory Storage
- eMMC - Embedded NAND Flash Memory Storage (Single Board Computers, SBCs)
- USB
- 3D XPoint (pronounced crosspoint)

Disk Sector Formats

- 512n - Native 512-byte sectors
- 4Kn - Native 4KiB sectors
- 512e - 4KiB sectors but 512-byte emulation
 - Most Common

4K block = 8 × 512-byte blocks								OS File System
0	1	2	3	4	5	6	7	Logical Blocks
4K Physical Sector #1								Physical Sectors

Figure 4: 512-byte Emulated Device Sector Size

Logical Blocks [0 to 7]								Logical Blocks [8 to 15]							
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4K Physical Sector #1								4K Physical Sector #2							

Figure 5: 512-byte Emulated Device Sector Size—Two “aligned” sectors

Partition Alignment

Since most modern operating systems will write in 4K blocks, it is important that each 4K logical block is aligned to a physical 4K block on the disk (see Figure 5). This is especially important because the 512e feature of the drive cannot prevent a partitioning utility from creating a misaligned partition. When misalignment occurs, a logical 4K block will reside on two physical sectors. In this case, a single read or write of a 4K block will result in a read/write of two physical sectors. The impact of a “read” is minimal, whereas a single write will cause two “Read-Modify-Writes” to occur, potentially impacting performance (see Figure 6)..

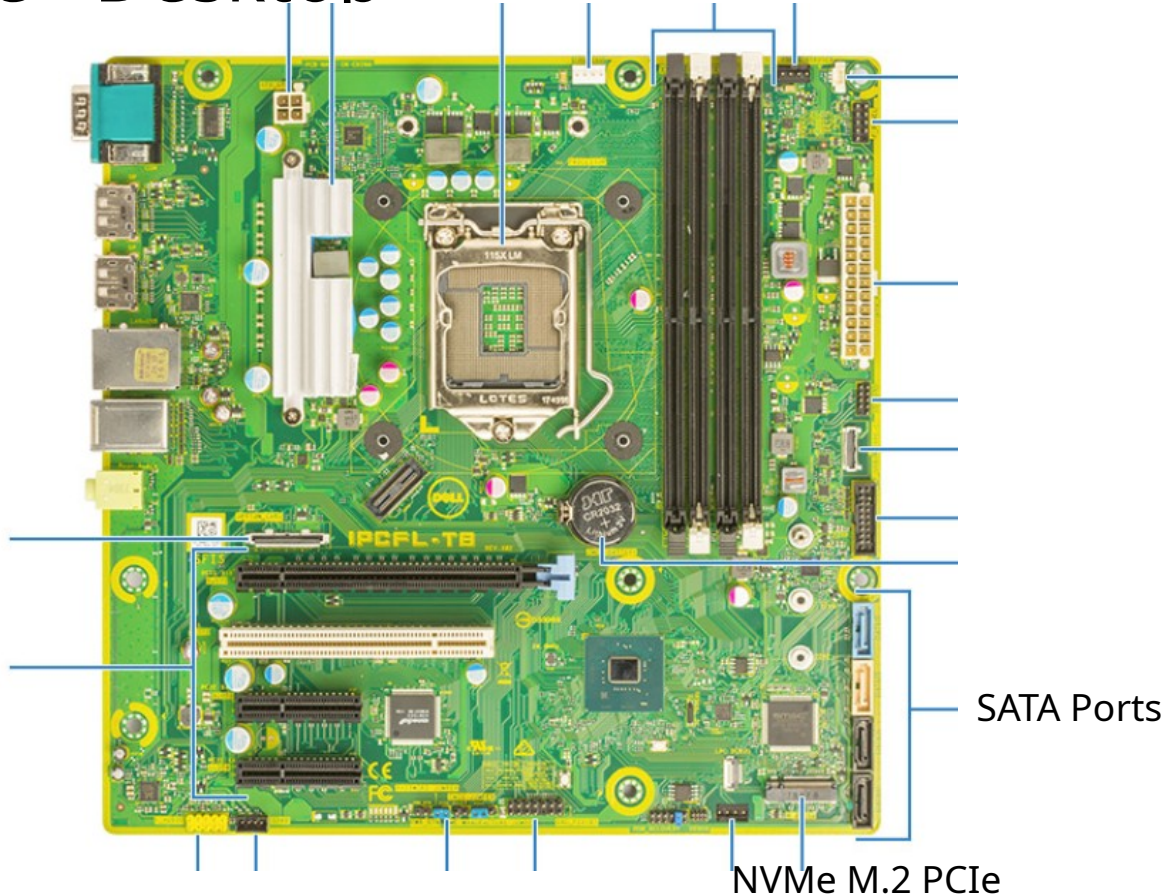
				4K logical block = 8 × 512-byte blocks [4:11]											
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4K Physical Sector #1								4K Physical Sector #2							

Figure 6: 512-byte Emulated Device Sector Size (MISALIGNED)

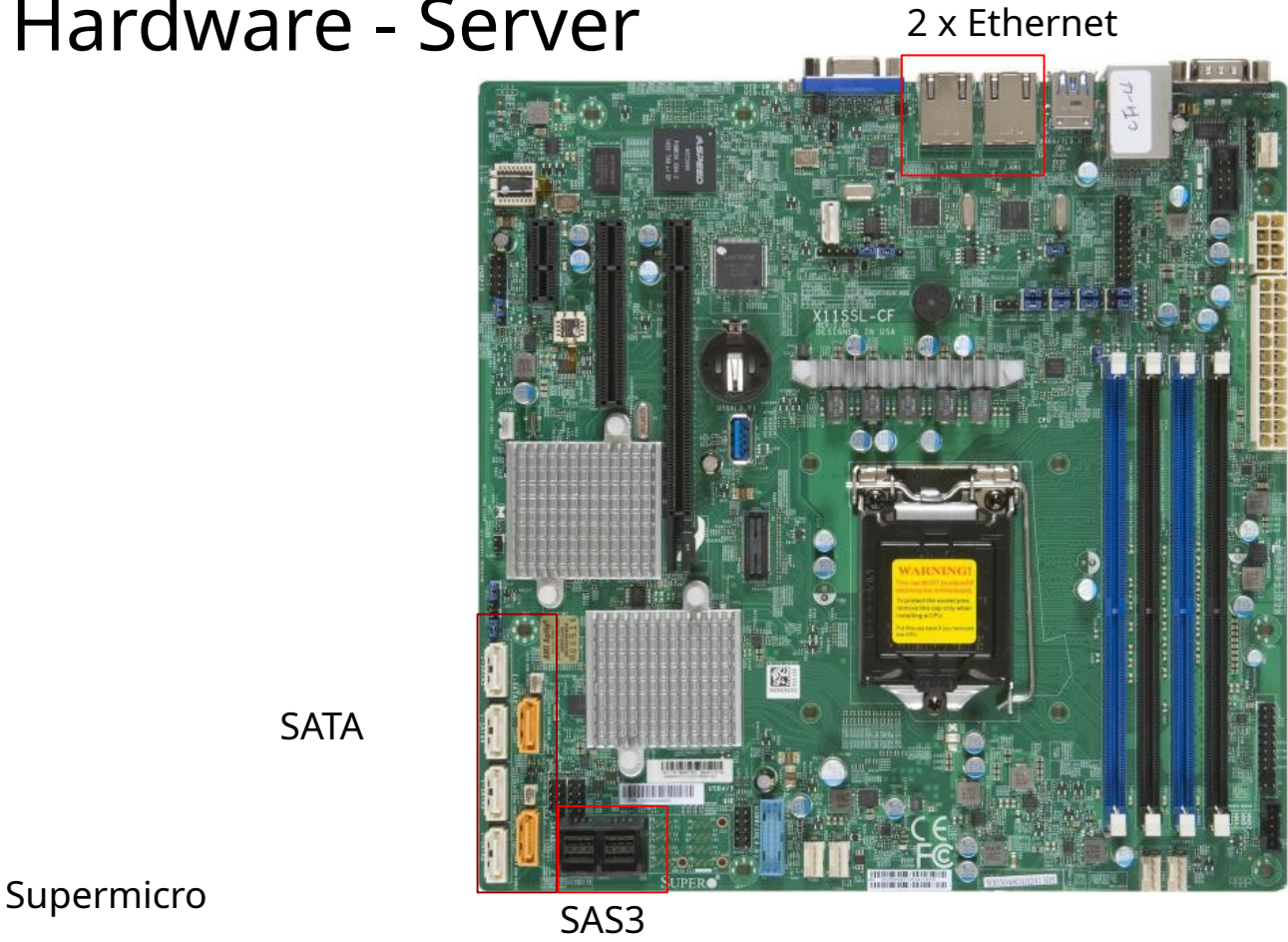
Optimal sectors

GNU Parted 2.1+ use “-a optimal” or “-a minimal” options

Hardware - Desktop



Hardware - Server



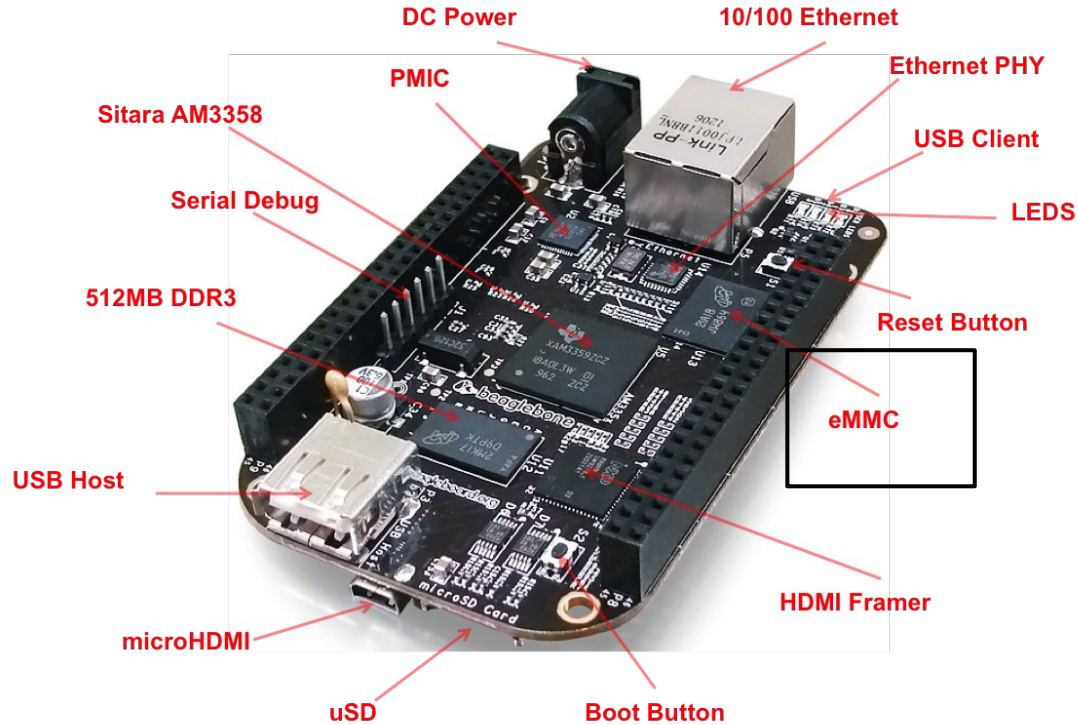
Hardware - Host Based Adapter

- 16 Ports
- 12Gb/s per port
- Just a bunch of disks (JBOD) 240 disks





Hardware SBC



Hardware

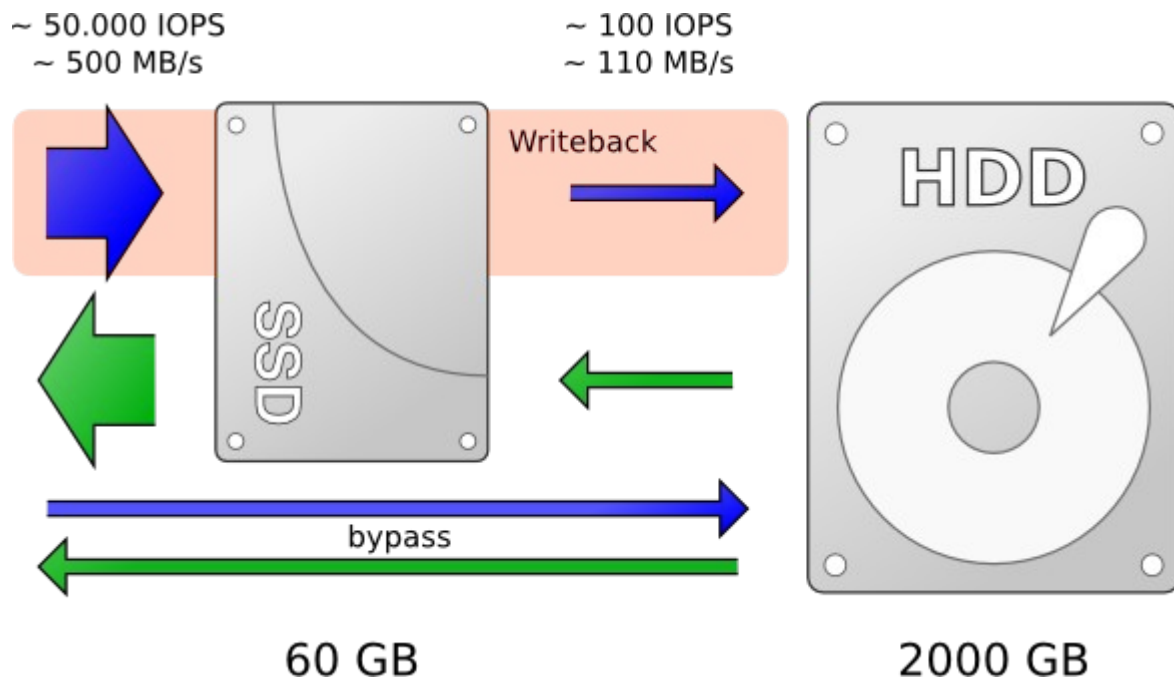
Characteristic	HDD	SSD
Typical size	< 16TB	< 2TB
Random access time ^a	8ms	0.25ms
Sequential read	200 MB/s	450 MB/s
Random read	2 MB/s	450 MB/s
IOPS ^b	150 ops/s	100,000 ops/s
Cost	\$0.03/GB	\$0.26/GB
Reliability	Poor	Poor ^c
Limited writes	No	In theory

a. Performance and cost values are as of mid 2017

b. I/O operations per second

c. Fewer whole-device failures than HDD, but more data loss

SSD + HDD bcache



Hardware Endurance

● Mean Time Between Failures (MTBF)

○ Widely Used in Industrial Engineering

- Robotics
- Aerospace
- Electrical

○ Denominated in hours

- HDD - WD Ultrastar® DC HC520 12TB, 2.5M hours MTBF
- SSD - Samsung MZ-PZA960BW 2TB, 2M hours MTBF

- MTBF less important for SSD because there are no mechanical components

○ Temperature and Power matters

- HDD Designed for 86°F
 - Higher temperature decreases reliability
- SSD for 0 to 133°F

Hardware Endurance

- SSD endurance and reliability better measured with TBW
- Terabytes Written (TBW)
 - Used for Flash Memory Storage
 - MTBF less relevant
 - Consumer drives - **~2,400 TBW** for a 4 TiB SSD
 - Enterprise Drives - **7,000 to 50,000 TBW** for a 4 TiB SSD
 - Optane Drives - Up to **584,000 TBW** for a 3.2 TiB SSD

Hardware Endurance

*The product shall achieve an Annualized Failure Rate - AFR - of 0.73% (Mean Time Between Failures - MTBF - of 1.2 Million hrs) when operated in an environment that ensures the HDA case temperatures do not exceed 40°C. Operation at case temperatures outside the specifications in Section 2.9 may increase the product Annualized Failure Rate (decrease MTBF). AFR and MTBF are population statistics that are **not relevant to individual units**.*

AFR and MTBF specifications are based on the following assumptions for business critical storage system environments:

- **8,760 power-on-hours per year. (365 days)**
- **250 average motor start/stop cycles per year. (on/off)**
- **Operations at nominal voltages. (Power supply and facility outages)**
- *Systems will provide adequate cooling to ensure the case **temperatures do not exceed 40°C**. Temperatures outside the specifications in Section 2.9 will increase the product AFR and **decrease MTBF**.*

/sys

- Pseudo-Filesystem that presents kernel objects in a filesystem hierarchy
 - Hardware
- Provides a common interface to devices
 - Scan
 - Power
- Devices
 - SATA - Disks
 - PCIe - GPUs, NVMe, Ethernet
 - i2c - Fans, LEDs, Temperature Sensors, IoT
 - SPI - Similar to i2c
 - GPIO - PWM, LEDs, etc.
- `lspci` - list pci devices

<i>/sys/block</i>	This subdirectory contains one symbolic link for each block device that has been discovered on the system.
<i>/sys/bus</i>	This directory contains one subdirectory for each of the bus types in the kernel.
<i>/sys/class</i>	Device classes, terminals, network devices, block devices, graphics devices, sound devices
<i>/sys/class/net</i>	Symbolic links representing one of the real or virtual networking devices
<i>/sys/dev</i>	Block and character devices <i>major-ID:minor-ID</i>
<i>/sys/devices</i>	Kernel Device Tree
<i>/sys/fs/cgroup</i>	Mount point for cgroups

/sys

```
root@cs447:/# tree -L 1 /sys
/sys
├── block
├── bus
├── class
├── dev
├── devices
├── firmware
├── fs
├── hypervisor
├── kernel
├── module
└── power

11 directories, 0 files
```

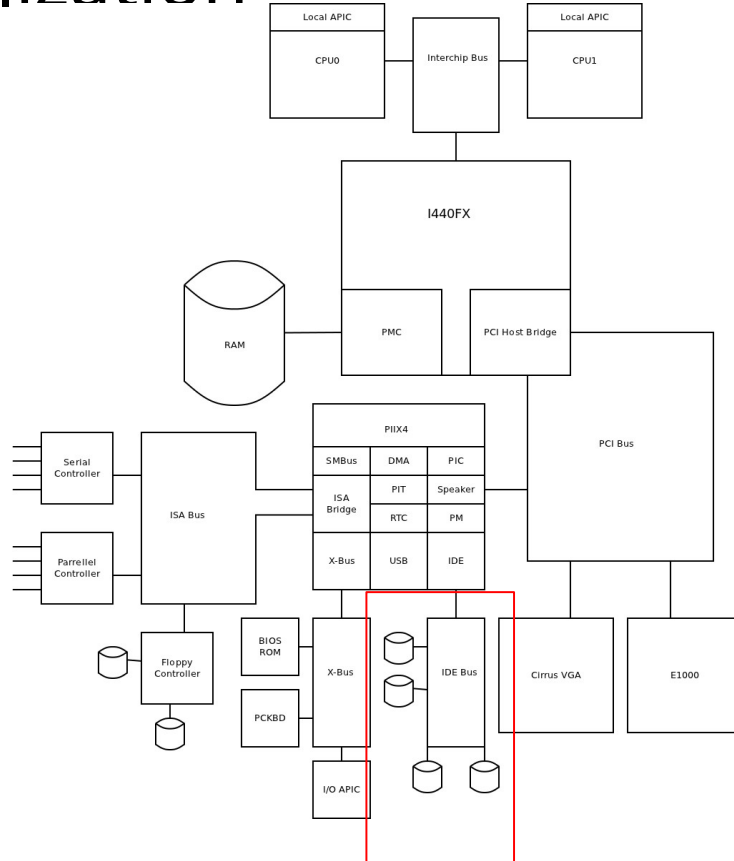
/sys/block

```
root@cs447:/# tree -L 1 /sys/block
/sys/block
├── fd0 -> ../devices/platform/floppy.0/block/fd0
├── loop0 -> ../devices/virtual/block/loop0
├── loop1 -> ../devices/virtual/block/loop1
├── loop2 -> ../devices/virtual/block/loop2
├── loop3 -> ../devices/virtual/block/loop3
├── loop4 -> ../devices/virtual/block/loop4
├── loop5 -> ../devices/virtual/block/loop5
├── loop6 -> ../devices/virtual/block/loop6
├── loop7 -> ../devices/virtual/block/loop7
├── sr0 -> ../devices/pci0000:00/0000:00:01.1/ata2/host1/target1:0:0/1:0:0:0/block/sr0
├── vda -> ../devices/pci0000:00/0000:00:04.0/virtio1/block/vda
└── vdb -> ../devices/pci0000:00/0000:00:05.0/virtio2/block/vdb

12 directories, 0 files
```

Virtual Drive - Why is attached to a PCI bus?

QEMU - Virtualization



```
newellz2@banyan:~$ tree -L 1 /sys/block/sda/device
/sys/block/sda/device
├── blacklist
├── block
├── bsg
├── delete
├── device_blocked
├── device_busy
├── dh_state
├── driver -> ../../../../../../../bus/scsi/drivers/sd
├── eh_timeout
├── evt_capacity_change_reported
├── evt_inquiry_change_reported
├── evt_lun_change_reported
├── evt_media_change
├── evt_mode_parameter_change_reported
├── evt_soft_threshold_reached
├── generic -> scsi_generic/sg0
├── inquiry
├── iocounterbits
├── iodone_cnt
├── ioerr_cnt
├── iorequest_cnt
├── modalias
├── model
├── ncq_prio_enable
├── power
├── queue_depth
├── queue_ramp_up_period
├── queue_type
├── rescan
├── rev
├── scsi_device
├── scsi_disk
├── scsi_generic
├── scsi_level
├── state
├── subsystem -> ../../../../../../../bus/scsi
├── sw_activity
├── timeout
├── type
├── uevent
├── unload_heads
├── vendor
├── vpd_pg80
├── vpd_pg83
└── wwid
```

9 directories, 36 files

Removing a disk

```
echo 1 > /sys/block/sda/device/delete #Remove a disk
```



```
newell12@banyan:~$ tree -L 1 /sys/devices/pci0000:00/0000:00:11.4/ata1/host0/scsi_host/host0  
/sys/devices/pci0000:00/0000:00:11.4/ata1/host0/scsi_host/host0
```

```
├── active_mode  
├── ahci_host_cap2  
├── ahci_host_caps  
├── ahci_host_version  
├── ahci_port_cmd  
├── can_queue  
├── cmd_per_lun  
├── device -> ../../../../host0  
├── eh_deadline  
├── em_buffer  
├── em_message  
├── em_message_supported  
├── em_message_type  
├── host_busy  
├── host_reset  
├── link_power_management_policy  
├── power  
├── proc_name  
├── prot_capabilities  
├── prot_guard_type  
├── scan  
├── sg_prot_tablesize  
├── sg_tablesize  
├── state  
├── subsystem -> ../../../../../../../../class/scsi_host  
├── supported_mode  
├── uevent  
├── unchecked_isa_dma  
├── unique_id  
└── use_blk_mq
```

```
3 directories, 27 files
```

/sys

- Scan a SATA port and find a disk.

- `echo "0 0 0" > /sys/devices/pci0000:00/0000:00:11.4/ata1/host0/scsi_host/host0`

- Remove a USB Device

- `echo 1 > /sys/devices/pci0000:00/0000:00:1a.0/usb1/1-1/remove`

- Remove PCI device

- `echo 1 > /sys/devices/pci0000:00/0000:00:1d.0/remove`

/sys

- Remove a device's driver

- `echo 1 > /sys/bus/pci/devices/0000:03:00.0/driver/unbind`

- Useful for VFIO passthrough

Back to disks...

```
newell122@banyan:~$ dmesg | grep sda
[ 1.969202] sd 0:0:0:0: [sda] 1875385008 512-byte logical blocks: (960 GB/894 GiB)
[ 1.969207] sd 0:0:0:0: [sda] Write Protect is off
[ 1.969208] sd 0:0:0:0: [sda] Mode Sense: 00 3a 00 00
[ 1.969215] sd 0:0:0:0: [sda] write cache: enabled, read cache: enabled, doesn't support DPO or FUA
[ 1.970573]   sda: sda1 sda2 sda3
[ 1.970794] sd 0:0:0:0: [sda] Attached SCSI disk
[ 4.010421] EXT4-fs (sda2): mounted filesystem with ordered data mode. Opts: errors=remount-ro
```

udev - creates /dev device files

```
root@banyan:~# udevadm info /dev/sda
P: /devices/pci0000:00/0000:00:11.4/ata1/host0/target0:0:0/0:0:0/block/sda
N: sda
S: disk/by-id/ata-SAMSUNG_MZ7KM960HAHP-0E005_S2NFXAG901025B
S: disk/by-id/wwn-0x5002538c4006676a
S: disk/by-path/pci-0000:00:11.4-ata-1
E: DEVLINKS=/dev/disk/by-id/ata-SAMSUNG_MZ7KM960HAHP-0E005_S2NFXAG901025B /dev/disk/by-path/pci-0000:00:11.4-ata-1
E: DEVNAME=/dev/sda
E: DEVPATH=/devices/pci0000:00/0000:00:11.4/ata1/host0/target0:0:0/0:0:0/block/sda
E: DEVTYPE=disk
E: ID_ATA=1
E: ID_ATA_DOWNLOAD_MICROCODE=1
E: ID_ATA_FEATURE_SET_HPA=1
E: ID_ATA_FEATURE_SET_HPA_ENABLED=1
E: ID_ATA_FEATURE_SET_PM=1
E: ID_ATA_FEATURE_SET_PM_ENABLED=1
E: ID_ATA_FEATURE_SET_SECURITY=1
E: ID_ATA_FEATURE_SET_SECURITY_ENABLED=0
E: ID_ATA_FEATURE_SET_SECURITY_ENHANCED_ERASE_UNIT_MIN=32
E: ID_ATA_FEATURE_SET_SECURITY_ERASE_UNIT_MIN=32
E: ID_ATA_FEATURE_SET_SMART=1
E: ID_ATA_FEATURE_SET_SMART_ENABLED=1
E: ID_ATA_ROTATION_RATE_RPM=0
E: ID_ATA_SATA=1
E: ID_ATA_SATA_SIGNAL_RATE_GEN1=1
E: ID_ATA_SATA_SIGNAL_RATE_GEN2=1
E: ID_ATA_WRITE_CACHE=1
E: ID_ATA_WRITE_CACHE_ENABLED=1
E: ID_BUS=ata
E: ID_MODEL=SAMSUNG_MZ7KM960HAHP-0E005
E: ID_MODEL_ENC=SAMSUNG\x20MZ7KM960HAHP-0E005\x20\x20\x20\x20\x20\x20\x20\x20\x20\x20\x20\x20\x20\x20\x20\x20\x20\x20\x20\x20
E: ID_PART_TABLE_TYPE=gpt
E: ID_PART_TABLE_UUID=d3cef820-c225-4406-9abe-e722d4a036ea
E: ID_PATH=pci-0000:00:11.4-ata-1
E: ID_PATH_TAG=pci-0000_00_11_4-ata-1
E: ID_REVISION=GXM1003Q
E: ID_SERIAL=SAMSUNG_MZ7KM960HAHP-0E005_S2NFXAG901025B
E: ID_SERIAL_SHORT=S2NFXAG901025B
E: ID_TYPE=disk
E: ID_WWN=0x5002538c4006676a
E: ID_WWN_WITH_EXTENSION=0x5002538c4006676a
E: MAJOR=8
E: MINOR=0
E: SUBSYSTEM=block
E: TAGS=:systemd:
E: USEC_INITIALIZED=1980290
```

Disk Information

hdparm -i /dev/sda #Get disk information

```
root@banyan:~# hdparm -i /dev/sda
/dev/sda:
Model=SAMSUNG MZ7KM960HAHP-0E005, FwRev=GXM1003Q, SerialNo=S2NFXAG901025B
Config={ Fixed }
RawCHS=16383/16/63, TrkSize=0, SectSize=0, ECCbytes=0
BuffType=unknown, BuffSize=unknown, MaxMultSect=16, MultSect=off
CurCHS=16383/16/63, CurSects=16514064, LBA=yes, LBASects=1875385008
IORDY=on/off, tPIO={min:120,w/IORDY:120}, tDMA={min:120,rec:120}
PIO modes: pio0 pio1 pio2 pio3 pio4
DMA modes: mdma0 mdma1 mdma2
UDMA modes: udma0 udma1 udma2 udma3 udma4 udma5 *udma6
AdvancedPM=no WriteCache=enabled
Drive conforms to: unknown: ATA/ATAPI-2,3,4,5,6,7

* signifies the current active mode
```



```
lsblk -o +MODEL,SERIAL
```

```
(base) [newellz2sa@ph-head-0 ~]$ lsblk -o +MODEL,SERIAL
```

NAME	MAJ:MIN	RM	SIZE	RO	TYPE	MOUNTPPOINT	MODEL	SERIAL
sda	8:0	0	372.6G	0	disk		INTEL SSDSC2BX40	BTHC71840B92400VGN
├─sda1	8:1	0	512M	0	part			
│ └─md127	9:127	0	512M	0	raid1	/boot		
├─sda2	8:2	0	16G	0	part			
│ └─md125	9:125	0	16G	0	raid1	[SWAP]		
└─sda3	8:3	0	356.1G	0	part			
└─md126	9:126	0	356G	0	raid1	/		
sdb	8:16	0	372.6G	0	disk		INTEL SSDSC2BX40	BTHC714101YG400VGN
├─sdb1	8:17	0	512M	0	part			
│ └─md127	9:127	0	512M	0	raid1	/boot		
├─sdb2	8:18	0	16G	0	part			
│ └─md125	9:125	0	16G	0	raid1	[SWAP]		
└─sdb3	8:19	0	356.1G	0	part			
└─md126	9:126	0	356G	0	raid1	/		
sdc	8:32	0	1.5T	0	disk		SSDSC2BB016T7R	PHDV716200ZK1P6EGN
└─md3	9:3	0	8.7T	0	raid6	/apps		
sdd	8:48	0	1.5T	0	disk		SSDSC2BB016T7R	PHDV716200XE1P6EGN
└─md3	9:3	0	8.7T	0	raid6	/apps		
sde	8:64	0	1.5T	0	disk		SSDSC2BB016T7R	PHDV716200Y91P6EGN
└─md3	9:3	0	8.7T	0	raid6	/apps		
sdf	8:80	0	1.5T	0	disk		SSDSC2BB016T7R	PHDV716202FU1P6EGN

Disk Information

- Self-Monitoring, Analysis and Reporting Technology (SMART)
 - Built into most ATA/SATA and SCSI/SAS hard drives
 - Monitor the reliability
 - Predict drive failures
 - Run self-tests

```
smartctl -x /dev/sda
```

```
root@banyan:~# smartctl -x /dev/sda
smartctl 6.6 2016-05-31 r4324 [x86_64-linux-4.15.0-65-generic] (local build)
Copyright (C) 2002-16, Bruce Allen, Christian Franke, www.smartmontools.org

=== START OF INFORMATION SECTION ===
Model Family:      Samsung based SSDs
Device Model:      SAMSUNG MZ7KM960HAHP-OE005
Serial Number:     S2NFXAG901025B
LU WWN Device Id: 5 002538 c4006676a
Firmware Version: GXM1003Q
User Capacity:     960,197,124,096 bytes [960 GB]
Sector Size:       512 bytes logical/physical
Rotation Rate:     Solid State Device
Device is:         In smartctl database [for details use: -P show]
ATA Version is:    ACS-2, ATA8-ACS T13/1699-D revision 4c
SATA Version is:   SATA 3.1, 6.0 Gb/s (current: 6.0 Gb/s)
Local Time is:     Tue Dec 31 18:44:44 2019 PST
SMART support is:  Available - device has SMART capability.
SMART support is:  Enabled
AAM feature is:    Unavailable
APM feature is:    Unavailable
Rd look-ahead is:  Enabled
Write cache is:    Enabled
ATA Security is:   Disabled, NOT FROZEN [SEC1]
Wt Cache Reorder:  Enabled
```

SMART Attributes Data Structure revision number: 1

Vendor Specific SMART Attributes with Thresholds:

ID#	ATTRIBUTE_NAME	FLAGS	VALUE	WORST	THRESH	FAIL	RAW_VALUE
5	Reallocated_Sector_Ct	PO--CK	100	100	010	-	0
9	Power_On_Hours	-O--CK	093	093	000	-	31185
12	Power_Cycle_Count	-O--CK	099	099	000	-	29
177	Wear_Leveling_Count	PO--C-	099	099	005	-	51
179	Used_Rsvd_Blk_Cnt_Tot	PO--C-	100	100	010	-	0
180	Unused_Rsvd_Blk_Cnt_Tot	PO--C-	100	100	010	-	7721
181	Program_Fail_Cnt_Total	-O--CK	100	100	010	-	0
182	Erase_Fail_Count_Total	-O--CK	100	100	010	-	0
183	Runtime_Bad_Block	PO--C-	100	100	010	-	0
184	End-to-End_Error	PO--CK	100	100	097	-	0
187	Uncorrectable_Error_Cnt	-O--CK	100	100	000	-	0
190	Airflow_Temperature_Cel	-O--CK	073	049	000	-	27
195	ECC_Error_Rate	-O-RC-	200	200	000	-	0
197	Current_Pending_Sector	-O--CK	100	100	000	-	0
199	CRC_Error_Count	-OSRCK	100	100	000	-	0
202	Exception_Mode_Status	PO--CK	100	100	010	-	0
235	POR_Recovery_Count	-O--C-	099	099	000	-	15
241	Total_LBAs_Written	-O--CK	099	099	000	-	30934598597
242	Total_LBAs_Read	-O--CK	099	099	000	-	56577552073
243	SATA_Downshift_Ct	-O--CK	100	100	000	-	0
244	Thermal_Throttle_St	-O--CK	100	100	000	-	0
245	Timed_Workld_Media_Wear	-O--CK	100	100	000	-	65535
246	Timed_Workld_RdWr_Ratio	-O--CK	100	100	000	-	65535
247	Timed_Workld_Timer	-O--CK	100	100	000	-	65535
251	NAND_Writes	-O--CK	100	100	000	-	43619670056

|||_| K auto-keep
|||_| C event count
|||_| R error rate
|||_| S speed/performance
|||_| O updated online
|||_| P prefailure warning

How do we use a disk?

- Check and note the serial number
 - Why? `/dev/disk/by-id`
- Insert
- Partition (most of the time)
 - `parted` - GPT and MBR
 - `fdisk` - Master Boot Record
 - `gdisk` - Like `fdisk` for GPT
- Create Filesystem
 - `mkfs -t ext4 -L myfs /dev/sda1`
- Mount
 - `mount /dev/sda1 /mnt`
- Create\Read\Update\Delete (CRUD) Files

Partitioning

- Disks are broken into segments called partitions

```


+-----+
-+
|               storage device with no partitions
|
+-----+
-+
0 start
end

```

<https://www.gnu.org/software/parted/manual/parted.html>

https://systemd.io/DISCOVERABLE_PARTITIONS/

Common partition types

Partition type	Mountpoint	gdisk's code	Partition type GUID 
Linux filesystem	Any	8300	0FC63DAF-8483-4772-8E79-3D69D8477DE4
EFI system partition	Any ¹	ef00	C12A7328-F81F-11D2-BA4B-00A0C93EC93B
BIOS boot partition	None	ef02	21686148-6449-6E6F-744E-656564454649
Linux x86-64 root (/)	/	8304	4F68BCE3-E8CD-4DB1-96E7-FBCAF984B709
Linux swap	[SWAP]	8200	0657FD6D-A4AB-43C4-84E5-0933C84B4F4F
Linux /home	/home	8302	933AC7E1-2EB4-4F13-B844-0E14E2AEF915
Linux /srv	/srv	8306	3B8F8425-20E0-4F3B-907F-1A25A76F98E8
Linux /var	/var ¹	8310	4D21B016-B534-45C2-A9FB-5C16E091FD2D
Linux /var/tmp	/var/tmp ¹	8311	7EC6F557-3BC5-4ACA-B293-16EF5DF639D1
Linux LVM	Any	8e00	E6D6D379-F507-44C2-A23C-238F2A3DF928
Linux RAID	Any	fd00	A19D880F-05FC-4D3B-A006-743F0F84911E
Linux LUKS	Any	8309	CA7D7CCB-63ED-4C53-861C-1742536059CC
Linux dm-crypt	Any	8308	7FFEC5C9-2D00-49B7-8941-3EA10A5586B7

Partitioning - Loop Device

- Kernel module loop
- Block device that maps its data blocks to a file
- Useful for a partitioned disk image stored in a file
- Backups!

```
root@banyan:~# grep LOOP /boot/config-4.15.0-72-generic
CONFIG_BLK_DEV_LOOP=y
CONFIG_BLK_DEV_LOOP_MIN_COUNT=8
CONFIG_BLK_DEV_CRYPTOLoop=m
CONFIG_NVME_TARGET_LOOP=m
# CONFIG_NVME_TARGET_FCLoop is not set
CONFIG_LOOPBACK_TARGET=m
# CONFIG_NET_DSA_LOOP is not set
CONFIG_SPI_LOOPBACK_TEST=m
CONFIG_RC_LOOPBACK=m
CONFIG_SND_ALoop=m
CONFIG_GREYBUS_LOOPBACK=m
CONFIG_IIO_TIGHTLOOP_TRIGGER=m
CONFIG_AUFS_BDEV_LOOP=y
```

.config - Linux/x86 4.15.18 Kernel Configuration

> Device Drivers > Block devices

Block devices

Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenus ----). Highlighted letters are hotkeys. Pressing <Y> includes, <N> excludes, <M> modularizes features. Press <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] built-in [] excluded <M> module < > module

^(-)

- <M> DataStor EP-2000 protocol
- <M> FIT TD-2000 protocol
- <M> FIT TD-3000 protocol
- <M> Shuttle EPAT/EPEZ protocol
- [*] Support c7/c8 chips
- <M> Shuttle EPIA protocol
- <M> Freecom IQ ASIC-2 protocol
- <M> FreeCom power protocol
- <M> KingByte KBIC-951A/971A protocols
- <M> KT PHd protocol
- <M> OnSpec 90c20 protocol
- <M> OnSpec 90c26 protocol
- <M> Block Device Driver for Micron PCIe SSDs
- <M> Compressed RAM block device support
- [*] Write back incompressible page to backing device
- <M> Myllex DAC960/DAC1100 PCI RAID Controller support
- <M> Micro Memory MM5415 Battery Backed RAM support
- <*> **Loopback device support**
- (8) Number of loop devices to pre-create at init time
- <M> Cryptoloop Support

+(+)

<Select>

< Exit >

< Help >

< Save >

< Load >

MBR

- Master Boot Record
- Originally from Microsoft's DOS
- Can only be used on disks < 2TiB
- Maximum of 4 Partitions
 - Workaround was to reserve one for 'logical partitions'
 - Windows must boot from a Primary Partition

parted

```
parted -s /dev/loop0 'help mklabel' #Creates a partition  
table
```

```
parted -s /dev/loop0 'mklabel msdos' #Master Boot Record  
Partition
```

```
parted -s /dev/loop0 'print'
```

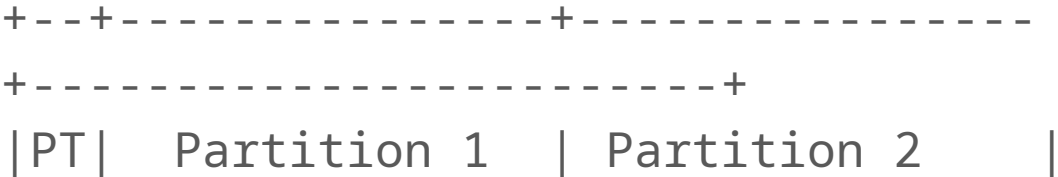
```
parted -s /dev/loop0 'mkpart primary 1 ext4 1M 200M' #Create  
Part
```

```
parted -s /dev/loop0 'unit G print'
```

```
parted -s /dev/loop0 'unit GiB print'
```



```
parted -s /dev/loop0 'mkpart primary fat32 200M 400M'
```



```
parted -s /dev/loop0 'unit MB print'
```

```
Model: Loopback device (loopback)
```

```
Disk /dev/loop0: 10737MB
```

```
Sector size (logical/physical): 512B/512B
```

```
Partition Table: msdos
```

```
Disk Flags:
```

Number	Start	End	Size	Type	File system	Flags
1	1.05MB	200MB	200MB	primary		
2	200MB	400MB	200MB	primary		lba

GPT - GUID Partition Table

- Described by Extensible Firmware Interface (EFI)
- Overcomes MBR shortcomings
- 64bit disk sector pointers, Max Partition size of 8 ZiB (zebibytes)
 - MBR uses 32bit
 - 8 ZiB is roughly 9.4 billion terabytes / 9.4 trillion gigabytes
- Supports up to 128 partitions
 - No primary, extended or logical partition types
- Partition Name
 - MBR does not support a Partition Name
- Partition Type
 - Autodiscovery

parted

```
parted -s /dev/loop0 'mklabel gpt # GPT Partition
```

```
parted -s /dev/loop0 'print'
```

```
parted -s /dev/loop0 'mkpart PART1 ext4 1M 200M' #Create  
Part
```

```
parted -a optimal -s /dev/loop0 'mkpart PART2 LVM 200M 400M'
```

```
#Create Part with optimal alignment
```

fstab - static information about the filesystems

Each filesystem is described on a separate line. Fields on each line are separated by tabs or spaces. Lines starting with '#' are comments. Blank lines are ignored. /etc/fstab and /etc/mtab

Fields

1. fs_spec - block special device or remote filesystem to be mounted.
2. fs_file - describes the mount point (target) for the filesystem. Can be "none".
3. fs_vfstype - type of the filesystem.
 - a. ext4, xfs, btrfs, f2fs, vfat, ntfs, hfsplus, tmpfs, sysfs, proc, iso9660, udf, squashfs, nfs, cifs, and many more.
4. fs_mntops - mount options associated with the filesystem.
 - a. defaults, noauto, user, owner, comment
5. fs_freq - used by dump(8) to determine which filesystems need to be dumped.
6. fs_passno - order in which filesystem checks are done at boot time. / should be 1.

getmntent(3) or libmount