6. File System

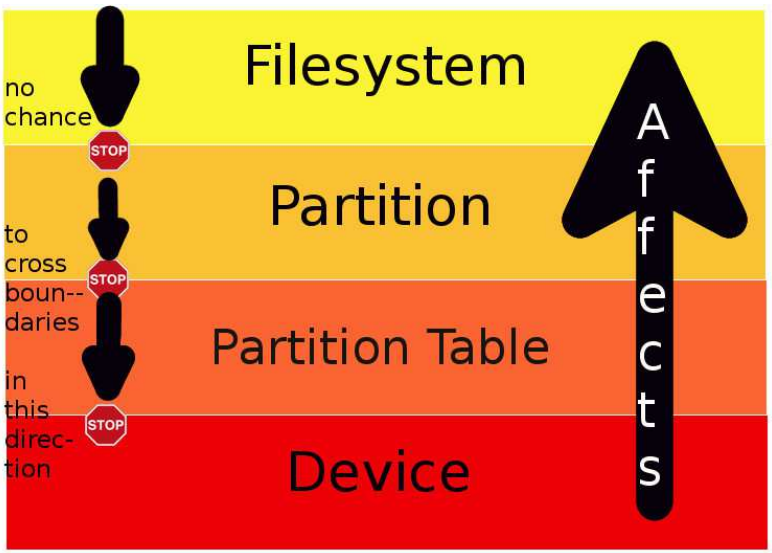
Drives and Capacity

as of 2014

Drive	Bandwidth (read)	Capacity	EUR/GB
hard disk drive	1.6 GB/s	60 GB. . . 4 TB	0.06. . . 0.20
solid state drive	2.7 GB/s	120 GB. . . 2 TB	0.70. . . 0.85
secure digital memory card	150 MB/s	4 GB. . . 128 GB	0.68. . . 0.85
USB memory stick	60 to 90 MB/s	4 GB. . . 256 GB	0.69. . . 2.00
digital versatile disk	61.7 MB/s (16x)	4.7 GB (1s, 1l)	0.69. . . 2.00

`http://en.wikipedia.org/wiki/Hard_disk_drive`
`http://www.intel.com/content/www/us/en/`
`solid-state-drives/solid-state-drives-ssd.html`
`http://www.tomshardware.com/charts/-usb-3.0-card-reader-charts-2014/`
`-01-Compact-Flash-Sequential-Read-MB-s,3542.html`
`http://www.tomshardware.com/reviews/DVD-Burner,2447-8.html`

Logical Layering



Partition Mess on Intel Systems

- first ,,OS" for Intel-based system was MS-DOS
- fundamental design error: four partitions on a hard disk named C:, D:, E:, F: (restriction 32 MB in MS-DOS 3.3 in 1987)
- disks grew bigger $\rightsquigarrow$more ,,logical" partitions G:, H:...
- disks grew still bigger $\rightsquigarrow$larger partitions
- MBR: still four *primary* partitions
- MBR: ,,extended" partition contains *logical* partitions
- MBR: disk limit 2 TB,
- MBR: no backup
- MBR: no error correcting code

UEFI Unified Extensible Firmware Interface

EFI: Itanium platform 1998 (Intel)

UEFI: April 2011 (Intel, AMD, Microsoft, Apple,...)

- GPT = GUID Partition Table
- pre-OS environment, including network capability
- 8 ZiB = 8000 EiB

SI-Prefixes: kilo-mega-giga-tera-peta-exa-zetta-yotta-...

IEEE1541: kibi-mebi-gibi-tebi-pebi-ebi-zebi-yobi-...

Linux / Windows 64-bit / HP-UX / HP-OpenVMS / Apple(Intel) / FreeBSD(GPT)

GUID = Globally Unique Identifier

What is a File System?

A file system is a *logical* unit of (background) memory.

Inodes are local to a file system.

A file system can live on

- a hard disk
- a floppy disk
- a CDROM
- a DVD
- a memory stick
- a part of RAM (RAMDISK)
- ...

FreeBSD Device Naming

The name determines what type of driver handles the storage device:

device name	drive type
ad	IDE (ATA, SATA) hard drives
da	USB mass storage, SCSI hard drives
acd	IDE CDROM drives
cd	SCSI CDROM drives
scd,mcd	non–standard CDROM drives
sa	SCSI tape drives
ast	IDE tape drives
fla	flash drives
aacd,mlxd,mlyd,idad,twed	RAID drives

Linux Device Naming

- /dev/hda first drive, first IDE controller
- /dev/sda first drive, first SATA/SCSI controller
  - first partition /dev/sda1.
  - second partition /dev/sda2.
- /dev/sdb 2nd drive
  - first partition /dev/sdb1.
  - second partition /dev/sdb2.

Type of device is irrelevant (HDD/CDROM).

Which devices are found?

Look at the boot messages.

Example:

```
# dmesg

ada0 at ata0 bus 0 scbus2 target 0 lun 0
ada0: <ST3250310AS 3.AAB> ATA-7 SATA 2.x device
ada0: 238475MB (488397168 512 byte sectors: 16H 63S/T 16383C)

ada1 at ata1 bus 0 scbus3 target 1 lun 0
ada1: <ST3500418AS CC38> ATA8-ACS SATA 2.x device
ada1: 476940MB (976773168 512 byte sectors: 16H 63S/T 16383C)

acd0: DVDROM <TSSTcorpDVD-ROM SH-D162C/TS04> at ata1-master UDMA33
acd1: CDRW <CW088D ATAPI CD-R/RW/V110F> at ata1-slave UDMA33
```


FreeBSD GPT Device and Partition Naming

/dev/ada0 is the first drive

Its first partition is /dev/ada0p1 (boot).

Its second partition is /dev/ada0p2 (usually /).

```
# gpart show ada0
=>       34  488397101  ada0  GPT  (233G)
         34       1024     1  freebsd-boot  (512K)
       1058   10485760     2  freebsd-ufs  (5.0G)
   10486818  209715200     3  freebsd-ufs  (100G)
  220202018   25165824     4  freebsd-ufs  (12G)
  245367842    8388608     5  freebsd-ufs  (4.0G)
  253756450  125829120     6  freebsd-ufs  (60G)
  379585570    8388608     7  freebsd-swap  (4.0G)
  387974178  100422957     8  freebsd-ufs  (48G)
```


Example: booting different partition

```
gpart unset -a bootme -i 2 ada0

gpart set -a bootme -i 6 ada0
```

File System (FS)

- lives within a partition
- maps directory-tree structure and files to disk
- inodes (meta–data) and directories/files (data)
- faetures: max FS size, max file size, crash recovery...

⇝several file system types

`http://linux-xfs.sgi.com`
`/projects/xfs/papers/xfs_white/xfs_white_paper.html`

File System Types

- FreeBSD
  - ufs (UNIX filesystem), FFS (Berkeley Fast Filesystem)
  - ext2fs
  - cd9660 – CD–ROM file system
  - new: ZFS (Sun Microsystems)
  - ...
- Linux
  - ext2 – standard linux FS
  - ext3 – journaling extension of ext2
  - ext4 – extension of ext3 (performance/features)
  - reiserfs – file system based on balanced trees
  - jfs – IBM's journaled FS
  - xfs – journaled FS
  - iso9660 – CD–ROM file system
  - ...

`http://www.tech-analyser.com/2011/10/`
`understanding-file-systemsntfs-fat.html`

`http://www.enterprisestorageforum.com/technology/features/`
`article.php/3849556/10-Reasons-Why-ZFS-Rocks.htm`

Show supported FS types

```
$ ls -l /sbin/mount_*
-r-xr-xr-x  /sbin/mount_cd9660
-r-xr-xr-x  /sbin/mount_fusefs
-r-xr-xr-x  /sbin/mount_mfs
-r-xr-xr-x  /sbin/mount_msdosfs
-r-xr-xr-x  /sbin/mount_nfs
-r-xr-xr-x  /sbin/mount_nullfs
-r-xr-xr-x  /sbin/mount_oldnfs
-r-xr-xr-x  /sbin/mount_udf
-r-xr-xr-x  /sbin/mount_unionfs
```

Partitioning/FS/Mounting

action	GPT
partition disk	`gpart`
init filesystem	`newfs/mkfs`
dev $\rightsquigarrow$ dir tree	`mount`

command	parameters
`gpart`	disk
`newfs`	partition, FS type
`mount`	partition, directory