Booting
PC style

Nov 2008

St. Louis UNIX User's Group

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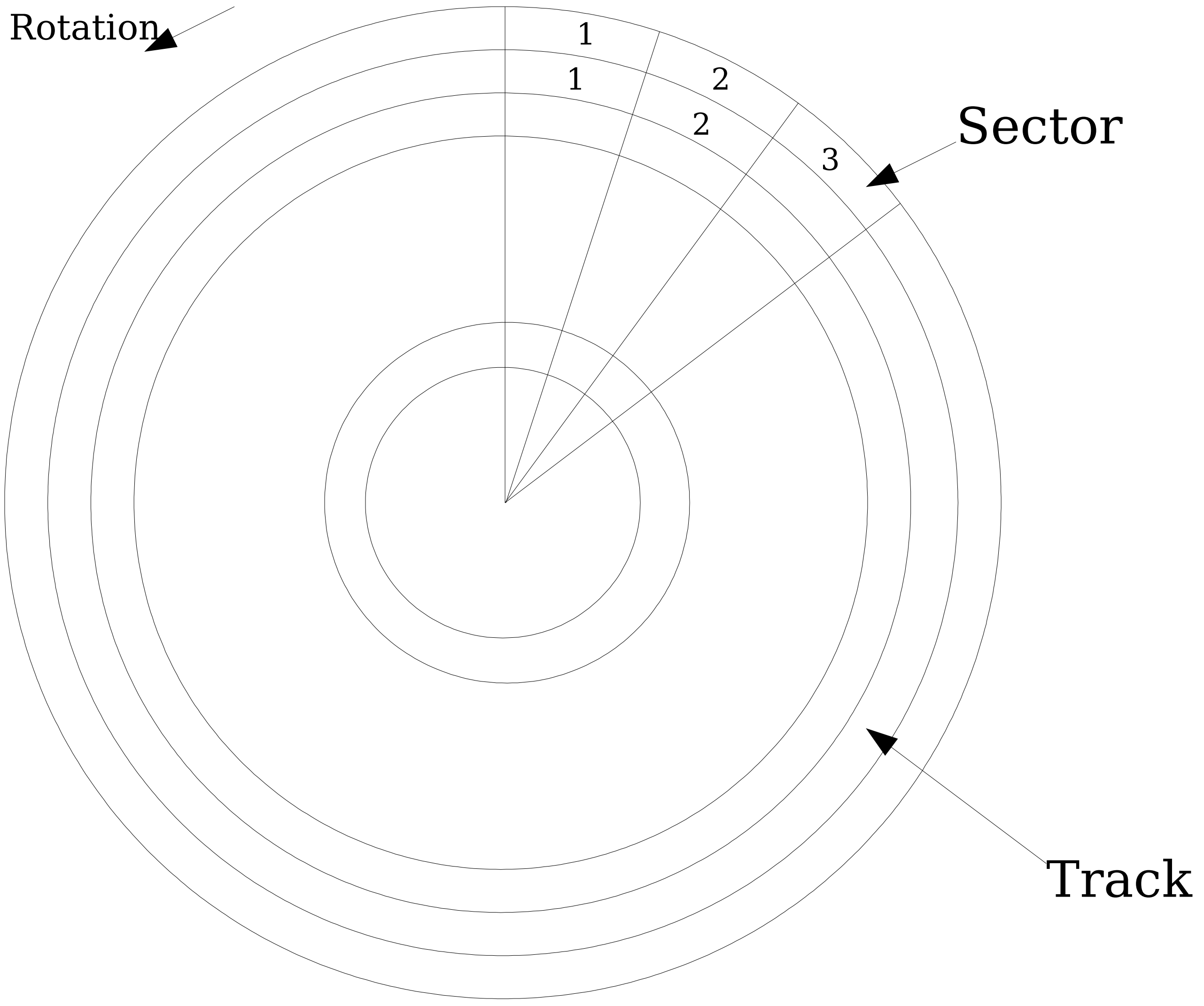
Constrants

- Only consider x86 PC Hardware
- Only consider PC capable of running DOS or Windows
- Only common BIOS types are considered
- Must be backward compatible

Layout of Disk

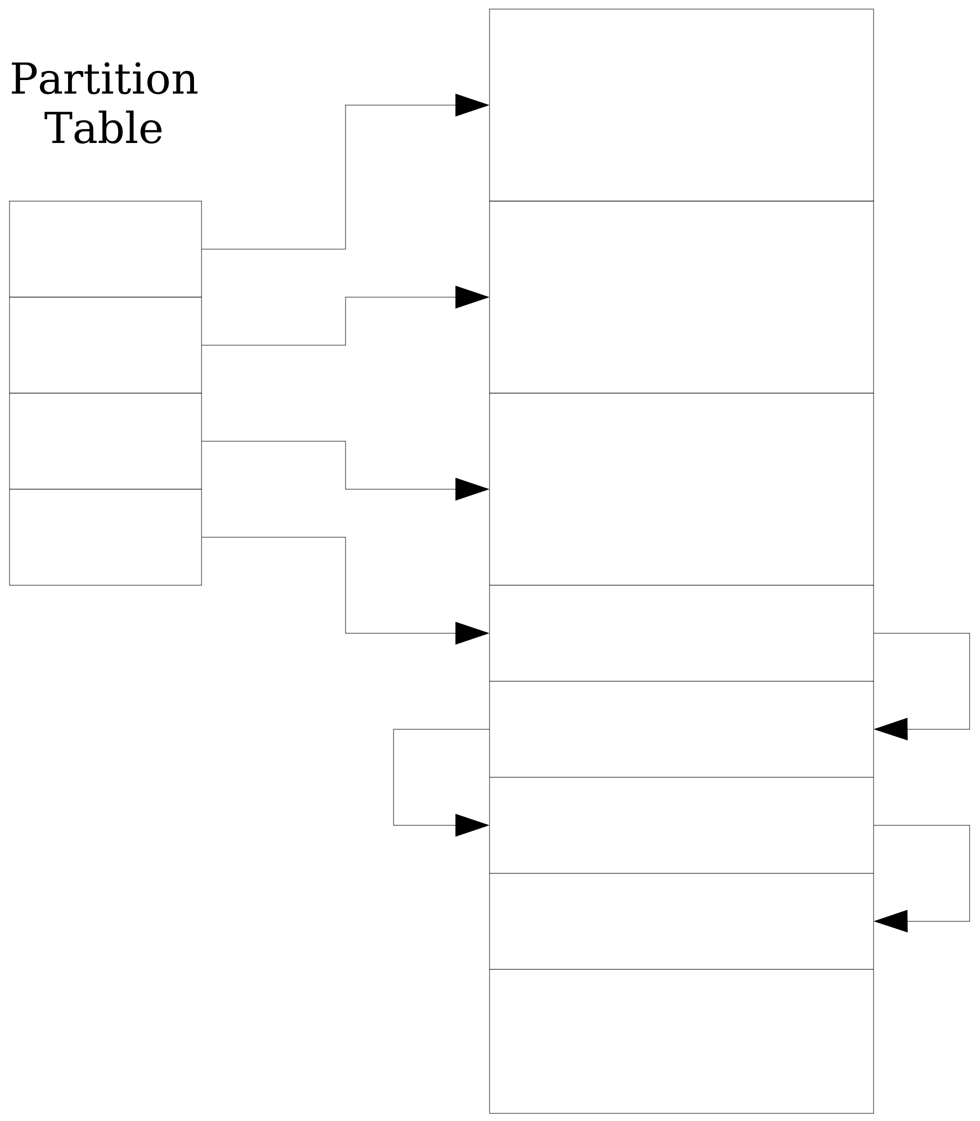


Track 0 is on the outside of a hard disk or floppy, on the inside of a CD or DVD.

Addressing on Disk

- CHS – Cylinder-Head-Section addressing
  - Cylinder = All Heads in the same Track
  - Track = 0-1023
  - Head = 0-255
  - Sector = 1-63
- LBA – Logical Block Addressing
  - One number 0-n addressing all sectors on the disk in order
- Disk Geometry
  - The specific number of Cylinders, Heads, and Sectors on a specific disk
  - Used to convert between CHS and LBA

Partition Table



1-4 Primary partitions

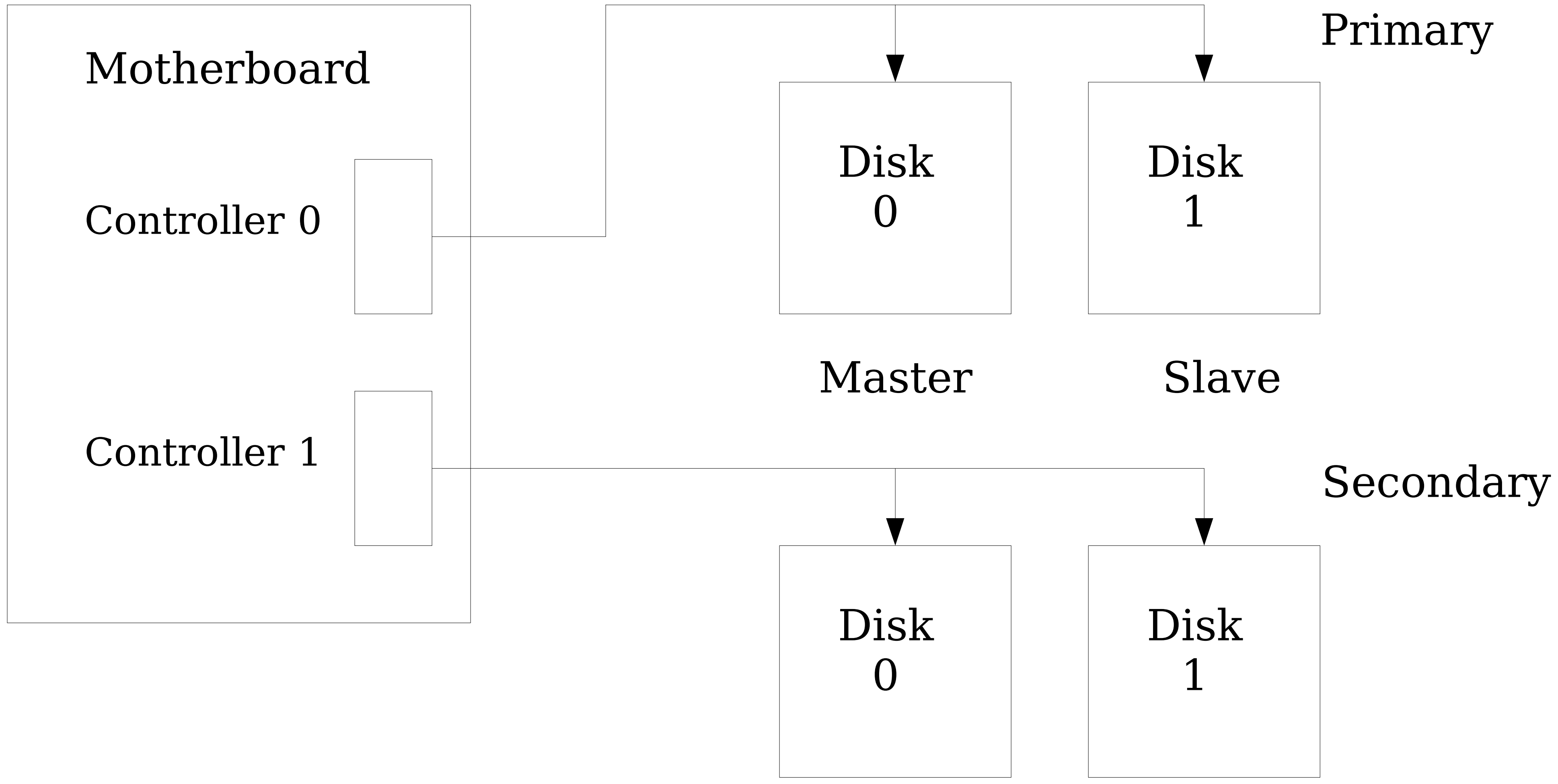
or

1-3 Primary partitions
plus
n Extended partitions
linked together

MBR

- Master Boot Record
  - Cylinder=0, Head=0, Sector=1 (LBA=0)
  - Contains
    - 1st stage boot (446 bytes)
    - Partition table
    - MBR Signature (0xaa55, on disk 55 aa)

Designation of Disks



Boot Sequence

- Normal boot sequence
  - BIOS checks
  - Search for bootable media
  - 1st stage boot from MBR
  - 2nd stage boot from partition (optional)
  - Loader (3rd stage) (optional)
- 1st and 2nd stages use BIOS for I/O and run in “real” mode (max addr = 1MB)

Loader's Assumptions

- Some loaders make assumptions about how the disk partition program lays out the disk
- Windows/Linux (FDISK)
  - Track(Cyl) 0 not used except for MBR
  - Primary Partition starts on Track(Cyl) boundary
- FreeBSD (other)
  - Partitions can start anywhere (LBA 1)

Stage 1 boot

- DOS/Windows
  - Loads 1 sector of the First track/cylinder of the Primary partition marked as active
- FreeBSD
  - Offers the user choice of which Primary Partition of which disk via a function key. Uses the previous choice after 5 seconds.
- VxWorks
  - Loads first sector of next track.

Stage 1 boot (cont)

- LILO, Grub, SystemCommander
  - Loads 2nd stage from second sector of track 0 which then extends itself into a full loader by reading up to 23 sectors of track 0
  - LILO, assumes the partitions are formatted ext2 and OS kernels are Linux, or will load second stage from any other Primary partition, called chain loading.
  - Grub and System Commander, like LILO except understand more file system and OS kernel types

Stage 2 boot

- DOS
  - Understands Windows file system formats (at least FAT)
  - Loads IO.SYS and MSDOS.SYS
- VxWorks
  - Understands FAT12 and FAT16 only
  - Loads BOOTROM.SYS
  - BOOTROM.SYS is a loader; it loads and initializes a complete VxWorks system
- LILO, Grub, SystemCommander & Windows
  - Loads same as in stage 1

Loaders

- The final target can be an OS image (usually compressed)
  - LILO – only understands Linux images, on pre-defined partition
  - Grub – understands a couple more images, but not FreeBSD
  - SystemCommander – understands even more
  - VxWorks BOOTROM.SYS – only understands VxWorks kernels and provides some kernel initialization (VxWorks kernels are not completely self initializating)
  - NTLDR – Windows loader (similar to LILO)

PXE

- PXE – Pre-eXecution Environment
  - Network booting, called “pixie”
  - Requires special ROM on network cards
  - Uses DHCP (bootp) to get information
  - Uses tftp (bootp) to get loader
  - BIOS is usually not used for actual boot

What else is there?

- EFI – Extensible Firmware Interface
  - Intel originated (Intel Boot Initiative)
  - Unified EFI (UEFI) Forum specification
  - First used with Intel for Itanium
  - Later used by:
    - HP for Itanium 2
    - Microsoft for 64-bit Windows
    - Apple for Intel-based Macintosh

EFI Framework

- OS, Boot Manager, Device Drivers in ROM
  - Controlled by well-known EFI variables
- GUID disk partition table
- \EFI\ disk partition, Fat32
- Applications on disk
  - Loaders
  - Shell
- Implementations are vendor specific