Booting
PC style

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St. Louis UNIX User's Group
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Constraints

• Only consider x86 PC Hardware
• Only consider PC capable of running DOS or Windows
• Only common BIOS types are considered
• Must be backward compatible
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
    - 1\textsuperscript{st} stage boot (446 bytes)
    - Partition table
    - MBR Signature (0xAA55, on disk 55 aa)
Designation of Disks

Motherboard

Controller 0

Controller 1

Disk 0

Disk 1

Master

Slave

Primary

Secondary
Boot Sequence

• Normal boot sequence
  - BIOS checks
  - Search for bootable media
  - 1\textsuperscript{st} stage boot from MBR
  - 2\textsuperscript{nd} stage boot from partition (optional)
  - Loader (3\textsuperscript{rd} stage) (optional)

• 1\textsuperscript{st} and 2\textsuperscript{nd} 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 2\textsuperscript{nd} 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 initializing)
  - 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