CSE321 Theory Assignment 01
Name-Abrar Ahmed
Id-23101354,Sec-33

Boot Workflow and Components:

BIOS System-Power to POST is executed by BIOS firmware.BIOS identifies a boot drive and reads the first sector (sector 0) of that drive (MBR). The small boot code loads in the BIOS and runs it. Typically, that MBR code locates the active partition and boots a second-stage bootloader (such as GRUB) installed to disk which loads the OS kernel into memory and then jumps to the kernel thus handoff complete.

UEFI System-Power on to firmware then runs a modular driver/firmware phase (UEFI drivers run). Booting still occurs but UEFI has far more extensive interfaces.They are loaded by reading the EFI System Partition (ESP) on the boot disk (a FAT32 partition that houses .efi programs).UEFI firmware boots a variety of EFI applications (a .efi file) either by using NVRAM boot entries or using a default path. That application may be a boot manager (Windows Boot Manager) or a bootloader (GRUB EFI).The EFI application loads the OS kernel and transfers the handoff using UEFI runtime features.

Architectural Comparison:

Design & capabilities-

BIOS-Old architecture, simple, runs 16-bit compatibility code, limited features, MBR based. It loads small boot code at LBA0 and then transfers to disk bootloader.Suitable to legacy hardware.

UEFI-New, modular, 32/64-bit, includes device drivers in firmware where they are integrated with services (allowing filesystems, network boot, secure boot) and runs applications in a filesystem (ESP) with .efi. Much more pliable and more powerful.

Partition table & disk size limits-

MBR: Stores partitioning information in the first 512-byte sector of the disk, supports up to four primary partitions and is constrained to 2 TiB per disk as it uses 32-bit LBA addressing in conventional arrangements. Corruption risk: single copy on launch of disk.

GPT: Is used along with UEFI. Employs 64-bit LBAs and GUIDs; can support anywhere between a small and very large number of partitions (max of 128 by default) and the size limits are very large. GPT stores several copies of the partition table in case of error.

Hardware & compatibility notes-

Very old motherboards and older OS may only support BIOS/MBR. Newer devices and new operating systems favour UEFI-GPT (Windows x64 since Windows 8, recent distributions of Linux, macOS use EFI). EFI has Secure Boot and more functionality available in the pre-boot environment.

Multi-Boot Systems:

There are two types of multibooting-

Boot manager strategy (menu & direct launch): A manager offers a menu which provides paths to kernels or .efi binaries and launches them unconditionally. Examples: rEFInd, systemd-boot. This is typical of UEFI machines since the firmware can execute EFI applications directly out of the ESP.

Chainloading method: Primary bootloader is loaded as a program and control transferred to it by a second bootloader. Typical example: GRUB on MBR that chain loads to the Windows Boot Loader; GRUB can boot another distro specific GRUB as well. The most common use of chainloading is when loading different families of operating systems or a combination of BIOS and UEFI-based methods.

Menu implementation choices-

Static config file: GRUB has a configuration file (grub.cfg) which has entries. It is either automatically updated or hand edited.

Dynamic detection: Managers are able to scan partitions to detect kernels or EFI binaries (rEFInd auto-detects kernels). This renders the addition of new entries in the OS automatic.

Detection challenges:

Different OSes place their loader in different locations (Windows in EFI\Microsoft, Linux distros in /boot or ESP), therefore detecting a specific OS almost always requires filesystem support and partition scanning.A signed boot and signature checking may block unsigned loaders.BIOS or UEFI and MBR or GPT are incompatible and chainloading can become complicated (one cannot boot the other without special workarounds).

Solutions:

Os-prober(being used by GRUB) finds and adds entries by scanning the disk automatically. Chainloading: bring up the boot into the native OS by using the first-level boot as a means of assuring reliability (ex: having the Windows Boot Manager hand off Windows boot). UEFI boot entries: on UEFI systems add NVRAM entries that point to each OSes .efi file; the firmware or a UEFI manager to present a menu.

References:

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