Operating Systems Fundamentals

The PC Boot Process
BIOS, CMOS and POST

Warm Boot and Cold Boot Process

- The **Boot Process** is how a computer system gets from no power to being operational.
  - It is the procedure that includes the transfer of the OS from mass storage into the main memory
- **Cold Boot** Process
  - Sequence used when PC is powered on from an OFF condition.
  - The POST sequence runs .
  - What is the difference between a Cold reboot and a Hard reboot?

- **Warm boot** is performed when computer is restarted
  - Commonly used when errors have occurred that can not be escaped from in any other manner.
  - Information stored in memory is maintained during warm boot process.
  - Warm boot is quicker than a cold boot.
  - Warm boot may not clear application errors.
  - The POST sequence is skipped
  - What is the difference between a Warm reboot and a Soft reboot?

BIOS – Basic Input Output System

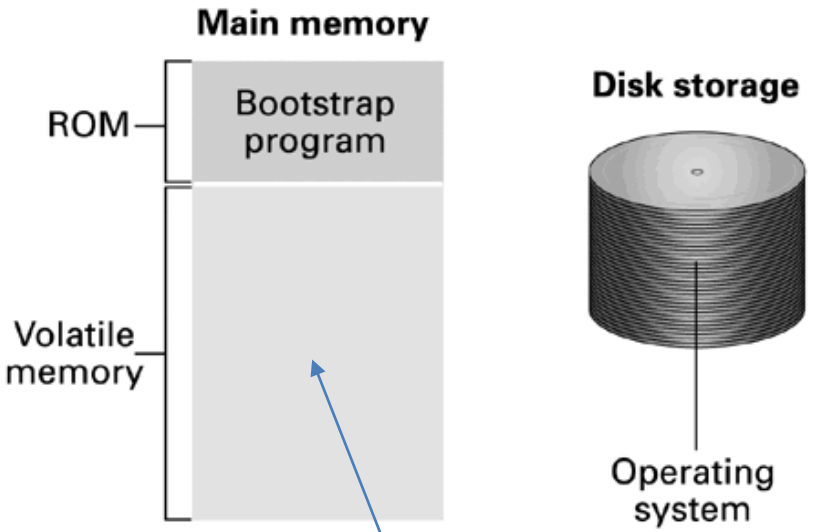
AMIBIOS
developed by American Megatrends Inc.

- The BIOS is special software stored on a chip located on the system unit
  - Its main role is to load the operating system
    - When you turn on your computer and the microprocessor tries to execute its first instruction, it has to get that instruction from somewhere
    - But since the Operating System is located on the hard disk before boot-up, the CPU cannot get this initial instruction from the OS
    - So the **BIOS** provides these initial instructions

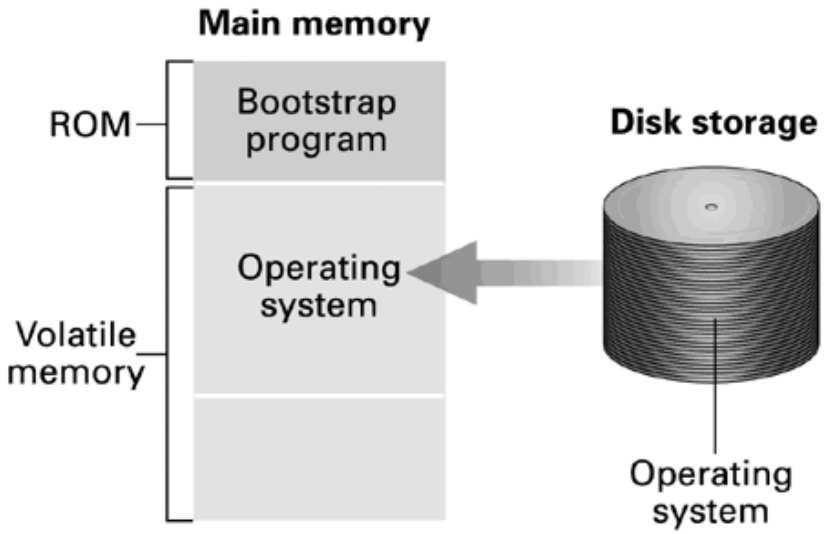
Such software which is stored on a chip is often referred to as **Firmware**.

Also referred to as the ‘ Bootloader layer’ (or Bootstrap)

The Booting Process



Step 1: Machine starts by executing the bootstrap program already in memory. Operating system is stored in mass storage.



Step 2: Bootstrap program directs the transfer of the operating system into main memory and then transfers control to it.

DRAM or HDD ?

POST - Power On Self Test

- The BIOS includes a test called POST (Power-On Self-Test)
  - The computer power-on self-test tests the computer to make sure it meets the necessary system requirements and that all hardware is working properly before starting the remainder of the boot process.
  - To complete POST, computer must have a working CPU, video card and RAM.
  - Beeps are used in POST to communicate success or failure.
    - http://www.bioscentral.com/beepcodes/amibeep.htm
  - Some beep codes are common and others are unique to that specific motherboard

PC Boot Steps

- **Step 1:** Power button is pressed.
  - This turns on the computer and ensures electricity can be supplied to the different components
  - If a warm boot is being performed, the computer does not need to wait for this as it has already been pressed and is operational
- **Step 2:**
  - Processor reads the base address of the ROM BIOS chips that contain computer start-up instructions
- **Step 3:**
  - Bios performs a series of tests, checking that the computer hardware is connected and operating correctly
  - POST - power-on self test
  - Checks buses, clocks, adaptor cards, RAM, Mouse, Keyboards, drives, external media, network

PC Boot Steps, continued

- **Step 4:** POST results are compared with data in a CMOS chip
  - A CMOS chip is a special chip that stores the expected system configuration results about the computer (RAM, disk drives, keyboard, monitor, current date and time, etc.)
  - Any differences between the two show either:
    - A system configuration change has happened e.g. additional RAM, etc
    - A problem exists that will prevent computer booting e.g. a missing CPU, no RAM, etc
  - Problems will be reported by Beeps, on-screen error messages and a failure to boot

N.B CMOS = Complementary metal–oxide–semiconductor

PC Boot Steps, continued

- **Step 5:**
  - The POST finishes determining that all the components are functioning properly and the CPU is successfully initialised.
  - On completing POST operations without error, BIOS knows the computer hardware is functioning correctly
  - The BIOS looks for an Operating System to load.
    - The BIOS typically looks to the CMOS to tell it where to find the OS
      - Usually on the C:
      - Other options?

PC Boot Steps, continued

- **Step 5:**
  - The POST finishes determining that all the components are functioning properly and the CPU is successfully initialised.
  - On completing POST operations without error, BIOS knows the computer hardware is functioning correctly
  - The BIOS looks for an Operating System to load. (via Master Boot Record)
    - The BIOS typically looks to the CMOS to tell it where to find the OS
      - Usually on the C:
      - Other options?
        - » USB, CD, DVD, Network

PC Boot Steps, continued

- **Step 6:**

  System files are loaded into main memory from a storage device. Then the kernel of the operating system is loaded

  - Kernel is the core component of the Operating System
  - Kernel will always remain in memory while the computer is powered on
  - (Optional) Additional components built on the Kernel functionality are then loaded to complete the Operating System
  - In older DOS PCs, once the OS initialises, the BIOS copies itself into memory (why?) and the OS takes control of the boot process.
    - Modern OS no longer uses the BIOS software for I/O access

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    Because it was used by bottom layers of the OS

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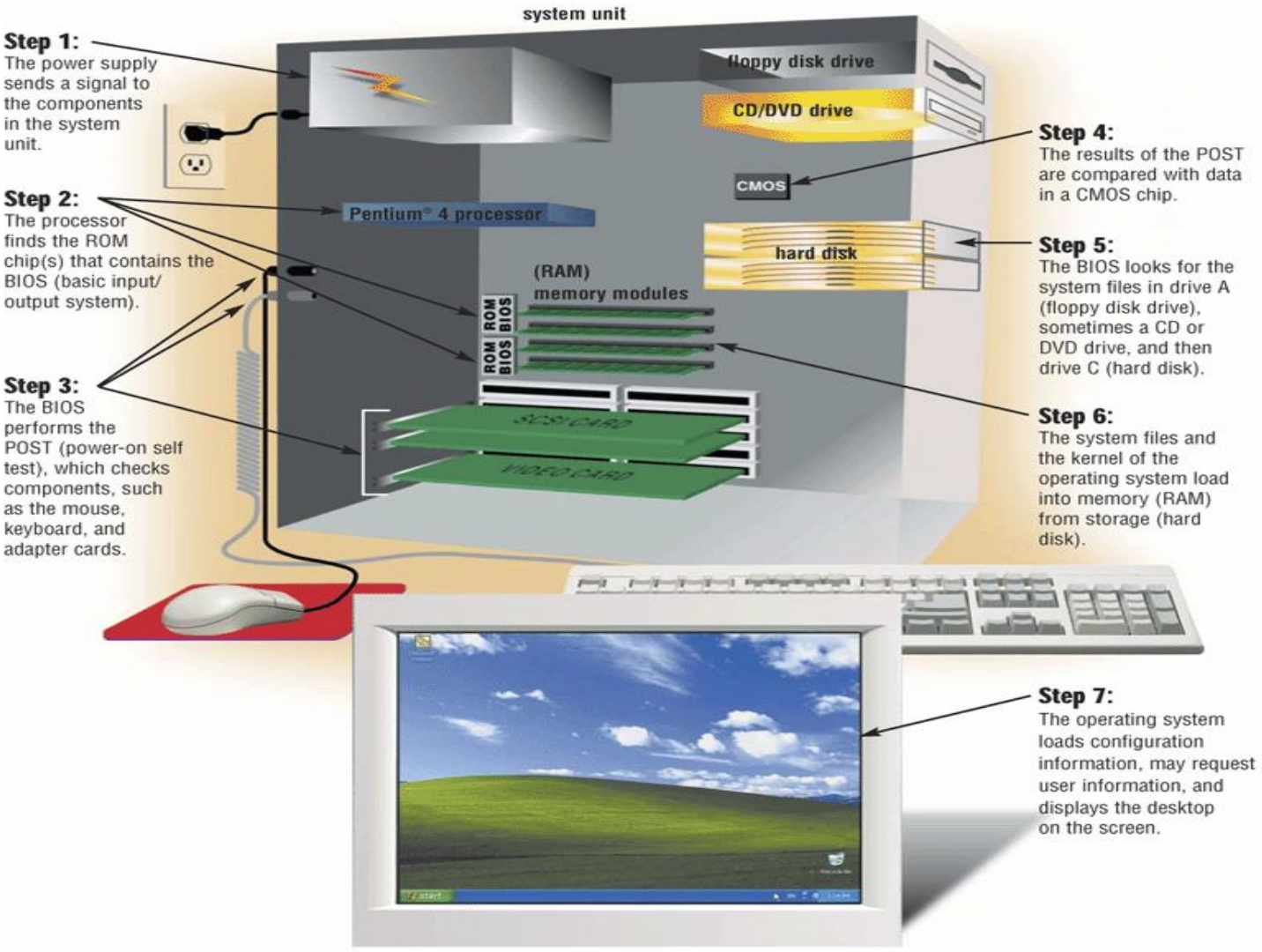
PC Boot Steps, continued

- **Step 7:** Operating System configuration information is loaded
  - On Windows this is stored in the Registry
    - Using Windows, type `Run → Regedit`
  - This configuration information consists of both computer settings and user settings
    - When logging on to the computer, profile and configuration information is loaded up as well
- **Step 8:** Operating system then executes programs in the start-up folder
  - You can customize the programs that start by adding or deleting programs from this folder
  - Easily accessible to the user
  - Improve loading performance of specific applications

PC Boot Steps, cont



Additional Boot States

- Additional boot states that may be present with Operating Systems (Warm Boots)

  - Standby
    - All non-essential devices are turned off.
    - Data in RAM is maintained active
    - For laptops, this entails using a small amount of battery power at all times
    - Quick re-initialisation of the computer as all data is readily accessible in RAM

  - Hibernate (lowest power usage state)
    - All user data present in RAM is written to hard disk by the OS
    - The computer is then 'turned off' saving battery/mains power
    - On powering back on, all data is moved from the hard disk back to RAM
    - Programs resume execution without knowledge of the powered off condition having occurred

  - **Q: What is Sleep Mode?**

  - **Q: Which mode will typically result in a faster boot time?**

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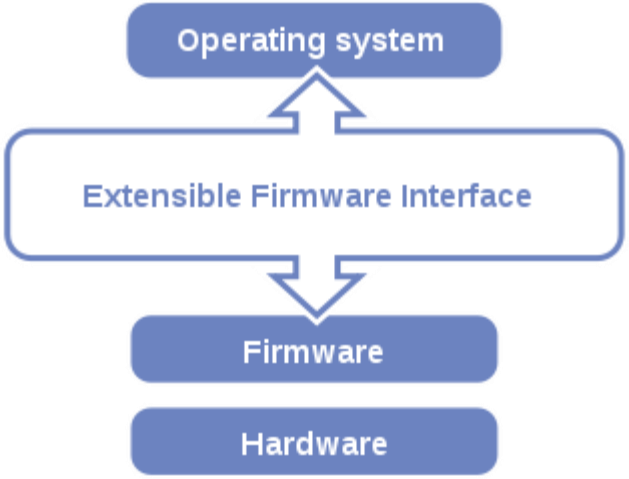
  - **Q: What is Sleep Mode?**
  - **Ans: Means different things depending on how much battery life remains.**
  - **Q: Which will typically result in a faster boot time?**
  - **Ans: Standby due to no HDD access required**

Latest Developments

- In 2000 Intel introduced a replacement for BIOS called the **EFI** (Extensible Firmware Interface)



- In 2007 the EFI specification is handed over to the **UEFI** Forum (Unified Extensible Firmware Interface Forum) of which Intel is a member.
  - EFI/UEFI provides:
    - More security (UEFI secure boot)
    - Faster boot time
    - Improved performance
    - Extensibility

Latest Developments

- In addition, UEFI.
  - It is a firmware interface specification
    - Standardized mechanism to bootstrap Operating System (OS) launch
    - Next-generation replacement for BIOS-based firmware
  - It is a platform independent specification.
  - It runs in long mode on x64 architecture
    - Great environment for using modern programming techniques and tools
    - By comparison, BIOS is a 16-bit real-mode environment
  - UEFI contains formally architected extensibility model
    - Adding in driver support is well-architected
    - Compared to ad-hoc extensibility in BIOS
  - UEFI enables the mainstream adoption of 64-bit computing.

Summary: Sequence of BIOS Operations

1. Turn on Power
2. CPU reads BIOS
3. BIOS performs series of tests (POST)
4. POST results compared with data in CMOS chip
   checking system configuration settings
5. Goes to MBR (Master Boot Record)
   to determine where OS is kept
6. Loads Operating System
7. Opens up GUI

N.B. Latest development is the UEFI