ECE437/CS481

INTRODUCTION TO OPERATING SYSTEM

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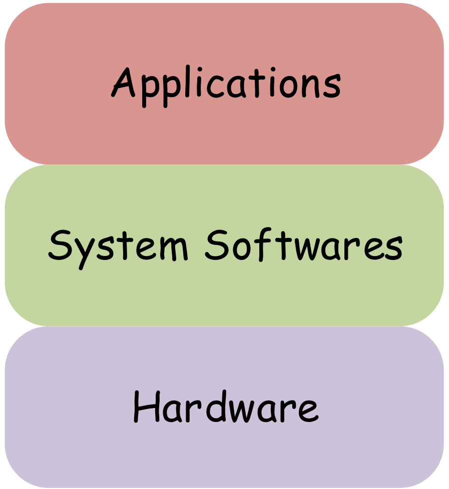
Concepts of Operating Systems



❑ Components of a computer system

- **Computer=Hardware + Software**
- **Software=Application + System Software**
- **Application:** software programs for users, e.g., web-browsers, games, word processors
- **System Software**: 1) control and work with computer hardware; 2) interface with applications
  - ✓ Types of System Software: Operating System (kernel), Software Utility, Device Drivers, Firmware…

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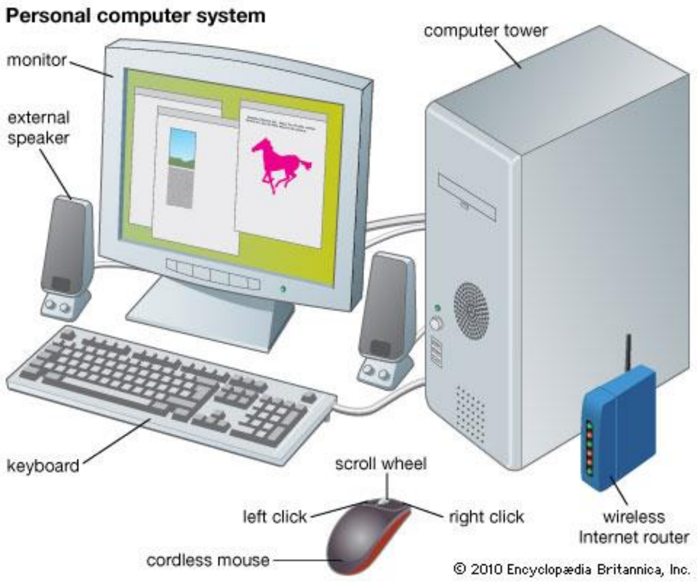
Concepts of Operating Systems

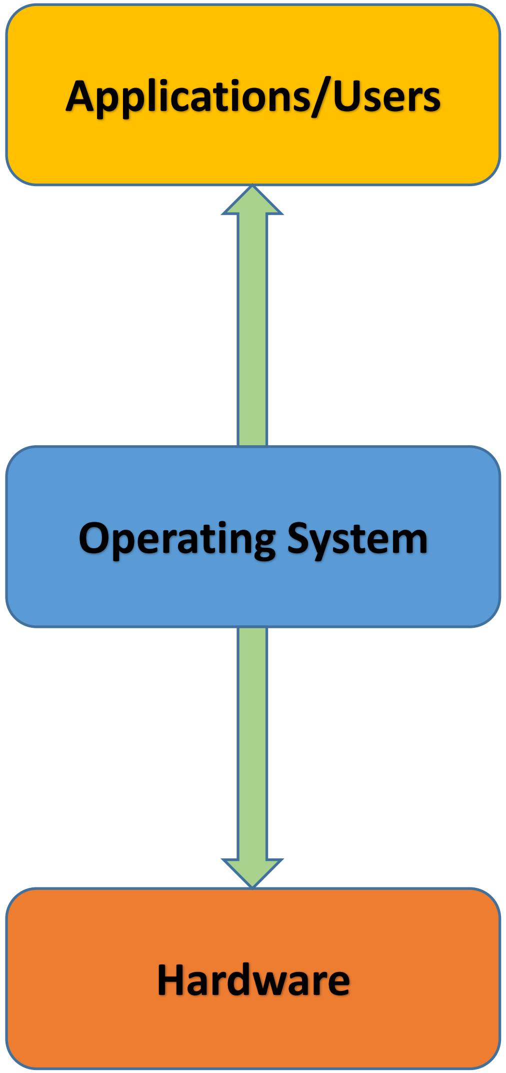
- ❑ Operating system = Important system software running at all times
  - ➢ As the 1st program to run before other programs
  - ➢ A program that provides controlled access to resources.
    - ✓ CPU, Memory
    - ✓ Display, keyboard, mouse
    - ✓ Persistent storage
    - ✓ Network



- ❑ Operating system goals:
  - ➢ Execute applications and make solving user problems easier.
  - ➢ Make the computer system convenient to use.
  - ➢ Use the computer hardware in an efficient manner.

Functionalities of OS

- ❑ Towards the upper --- Users
  - ➢ Provide the high-level services of an abstract machine
  - ➢ Build a nice environment with
    - ✓ convenient to use
    - ✓ fast response
- ❑ Towards the lower --- Machine
  - ➢ Manage resources such that
    - ✓ Be fair
    - ✓ Be efficient



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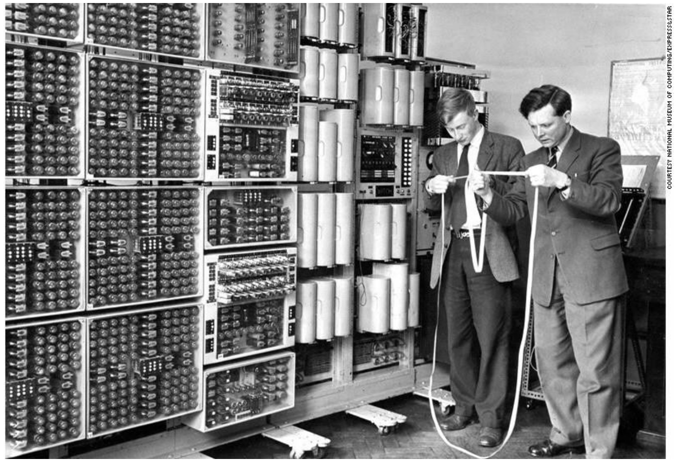
Functionalities of OS

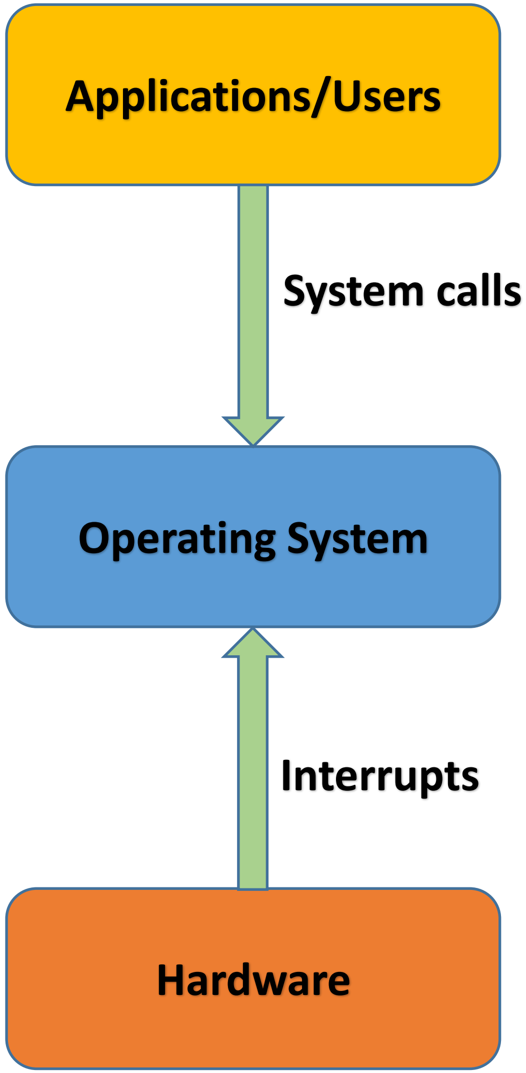
- It's not easy to make both parts happy
  - At early days, hardware is expensive and dummy
  - At current days, human resources are expensive and hardware become powerful and cheap.



  - Key point: to make a good trade-off

Accessing OS

- From users/apps to OS
  - System calls
    - ✓ Requests made to OS
    - ✓ OS process the system calls, may issue commands to hardware
- From hardware to OS
  - Interrupts
    - Event reported to OS
    - OS process the interrupts, may issue upcalls to applications



Kernel AND OS

- ❑ A kernel is a central component of an OS
  - ➢ It manages the core features of an OS, i.e., providing the most basic level of control over all of the computer's hardware devices with the help of the firmware and device drivers.

- ❑ Kernel + Utilities →OS.
  - ➢ The complete package becomes an OS
    - ✓ Linux kernel,
    - ✓ File-system utilities,
    - ✓ GUI desktops,
    - ✓ Sysadmin commands
    - ✓ Text editors,
    - ✓ Compilers,
    - ✓ …

Types of OS

- Real-Time OS
  - Installed in special purpose embedded systems like robots, cars, and modems.
- Single-user and single-task OS
  - Installed on single-user devices like phones.
- Single-user and multitask OS
  - Installed on contemporary personal computers.
- Multi-user OS
  - Installed in network environments where many users have to share resources (e.g., server OS).
- Network OS
  - Share data in a network.
- Internet/Web OS
  - Run all of its applications and services through the Internet .
- Mobile OS
  - Run on mobile phones, tablets and other mobile devices.

Startup Computer & OS

❑ Initial startup problem

- CPU could execute instructions in main memory, but main memory is volatile.

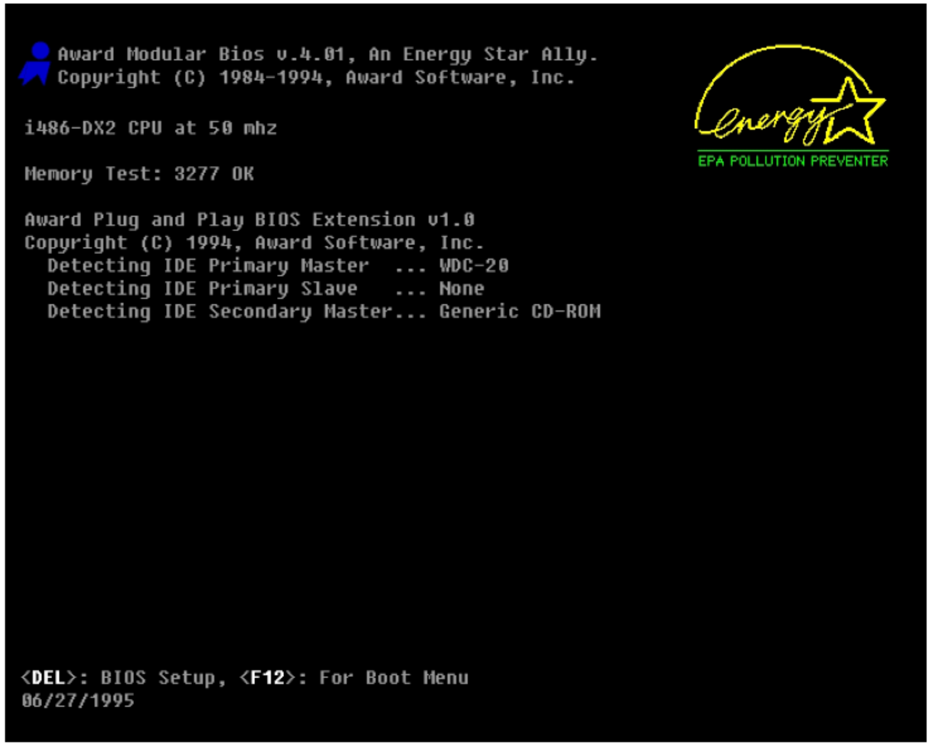
❑ Solution for startup

- Store the boot codes (generally known as Basic Input Output System (BIOS)) in a non-volatile storage (e.g., EPROM/ROM) to be executed.
- **Bootstrapping**: CPU loads and processes boot codes from the non-volatile storage.
- EPROM/ROM is used as the non-volatile storage to store boot codes.

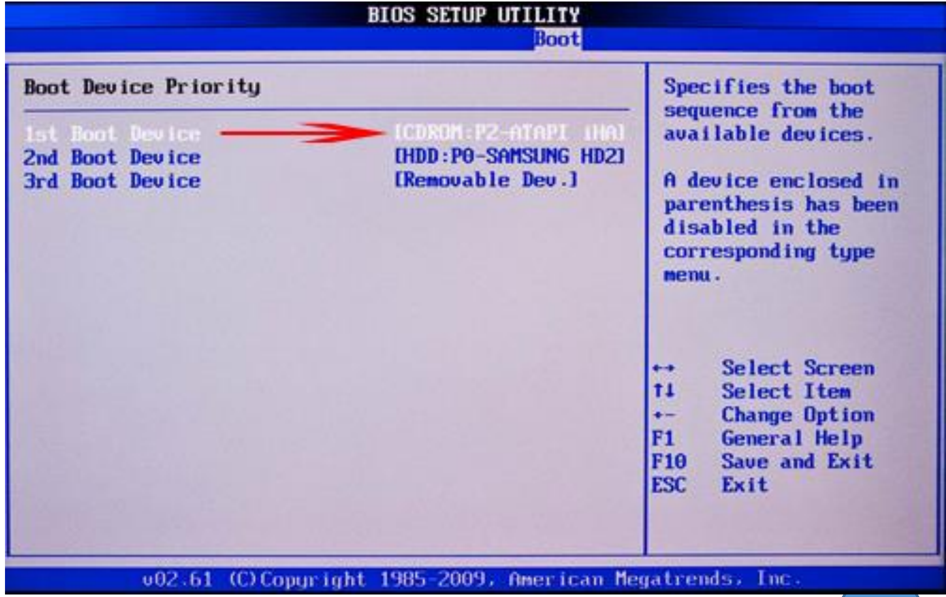
Startup Computer & OS

❑ Major Tasks of BIOS

- ➢ Display start-up screen.
- ➢ Configure Plug & Play devices: PCIe, USB, SATA.
- ➢ Power-on self-test (POST).
- ➢ Sequentially searching the boot device (e.g., hard disk, floppy disk, u-disk) that contains the operating system.
- ➢ Load block 0 (Master Boot Record) from a hard disk and jump there to load the operating system.



```
Award Modular Bios v.4.01, An Energy Star Ally.
Copyright (C) 1984-1994, Award Software, Inc.

i486-DX2 CPU at 50 mhz

Memory Test: 3277 OK

Award Plug and Play BIOS Extension v1.0
Copyright (C) 1994, Award Software, Inc.
  Detecting IDE Primary Master   ... WDC-20
  Detecting IDE Primary Slave    ... None
  Detecting IDE Secondary Master... Generic CD-ROM




<DEL>: BIOS Setup, <F12>: For Boot Menu
06/27/1995
```



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                        BIOS SETUP UTILITY
                                      Boot

 Boot Device Priority                          Specifies the boot
                                               sequence from the
 1st Boot Device          [CDROM:P2-ATAPI iHA] available devices.
 2nd Boot Device          [HDD:P0-SAMSUNG HD2]
 3rd Boot Device          [Removable Dev.]     A device enclosed in
                                               parenthesis has been
                                               disabled in the
                                               corresponding type
                                               menu.


                                              ↔    Select Screen
                                              ↑↓   Select Item
                                              +-   Change Option
                                              F1   General Help
                                              F10  Save and Exit
                                              ESC  Exit

        v02.61 (C)Copyright 1985-2009, American Megatrends, Inc.
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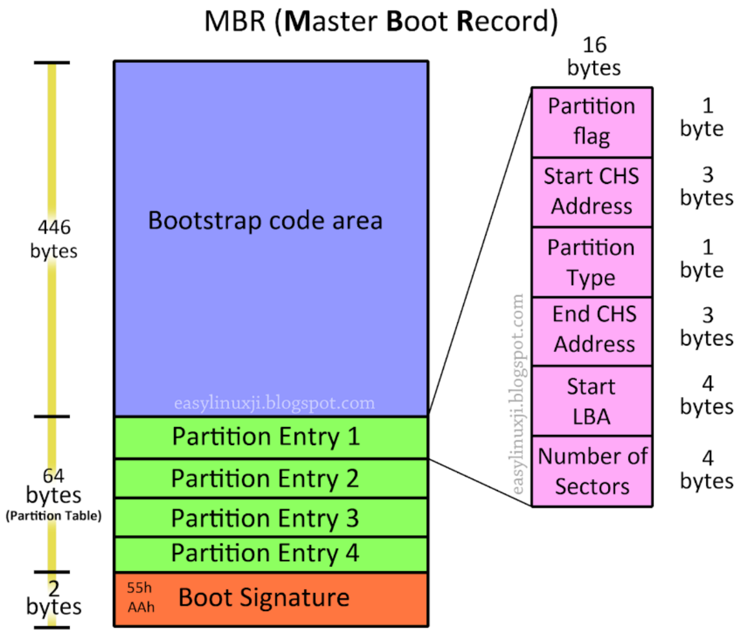
❑ What is Master Boot Record (MBR)?

- ➢ MBR (512 bytes) is the information in the first sector of any hard disk that identifies how and where an operating system is located so that it can be loaded into the computer's RAM.

- ➢ MBR consists of three parts, i.e., Boot Loader, Partition Table, and Magic Number.

  - ✓ Bootloader/Bootstrap code area (446 bytes) is a program that loads an operating system.
  - ✓ Partition table (64 bytes) records partition information of the hard disk.
  - ✓ Magic number/Boot Signature (2 bytes) marks the device as a valid bootable media. An invalid magic number indicates a corrupted or missing MBR.



Startup Computer & OS

- ❑ Summarize the procedure of startup a computer/OS
  --- (OS is stored in the hard disk)

  - ➢ Once a computer is powered on, the CPU executes the BIOS program in the EPROM/ROM.

  - ➢ The BIOS program initializes the communications, conducts POST, and loads MBR.

  - ➢ The bootloader in MBR takes over from the BIOS by scanning the partition table to find active partition and executing the codes in the active partition to load the OS from a specific file on the disk.

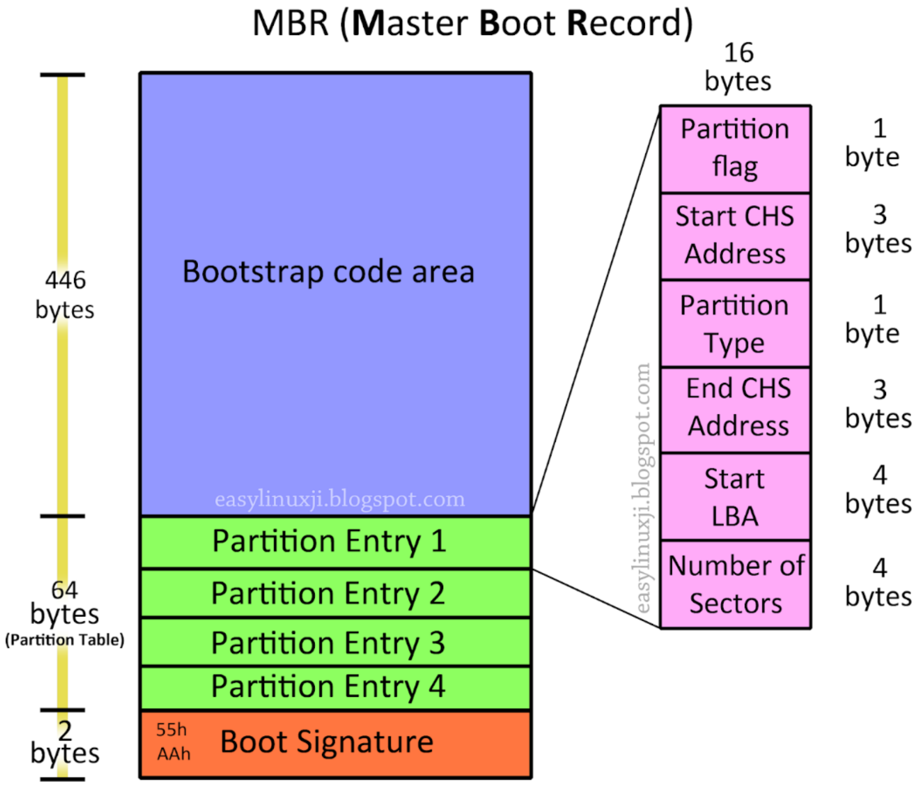
  - ➢ The OS initializes itself and takes control over all the hardware.

Startup Computer & OS

❑ Drawbacks of Master Boot Record (MBR)

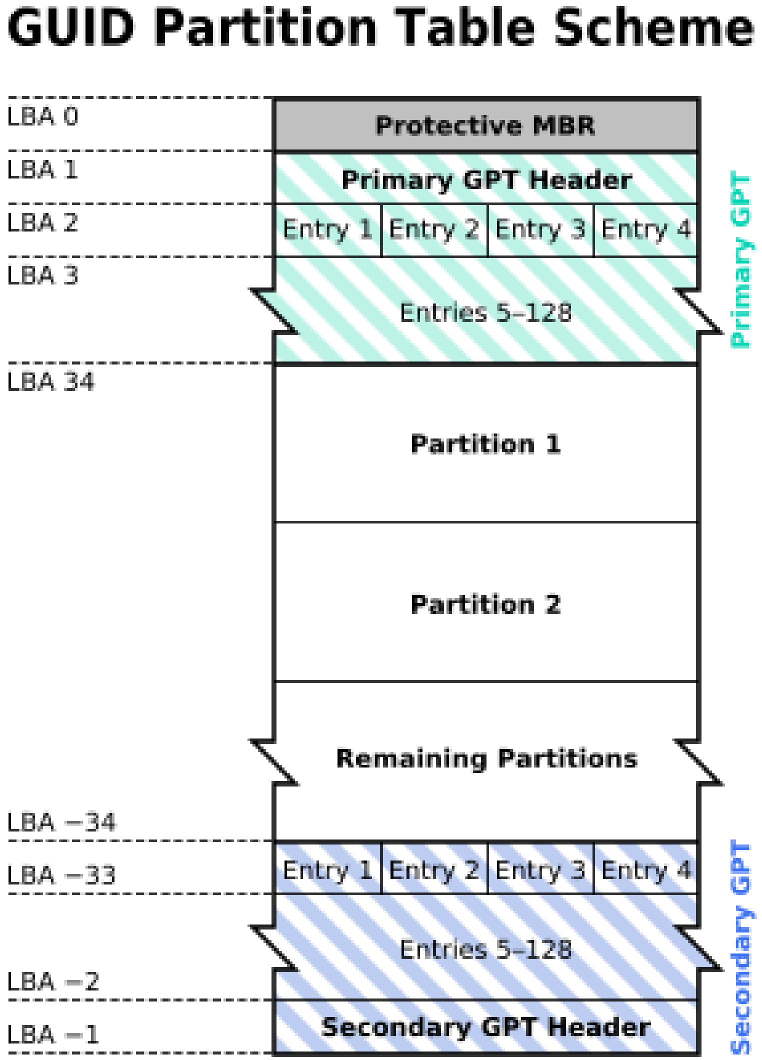
- ➢ There are at most 4 primary partitions on an MBR disk.

- ➢ If the size of a sector is 512 Bytes, then the largest partition capacity that MBR can express is 2TB.
  - ✓ 2^{4*8} sectors* 512 Bytes/sector=2^{41} B=2 TB



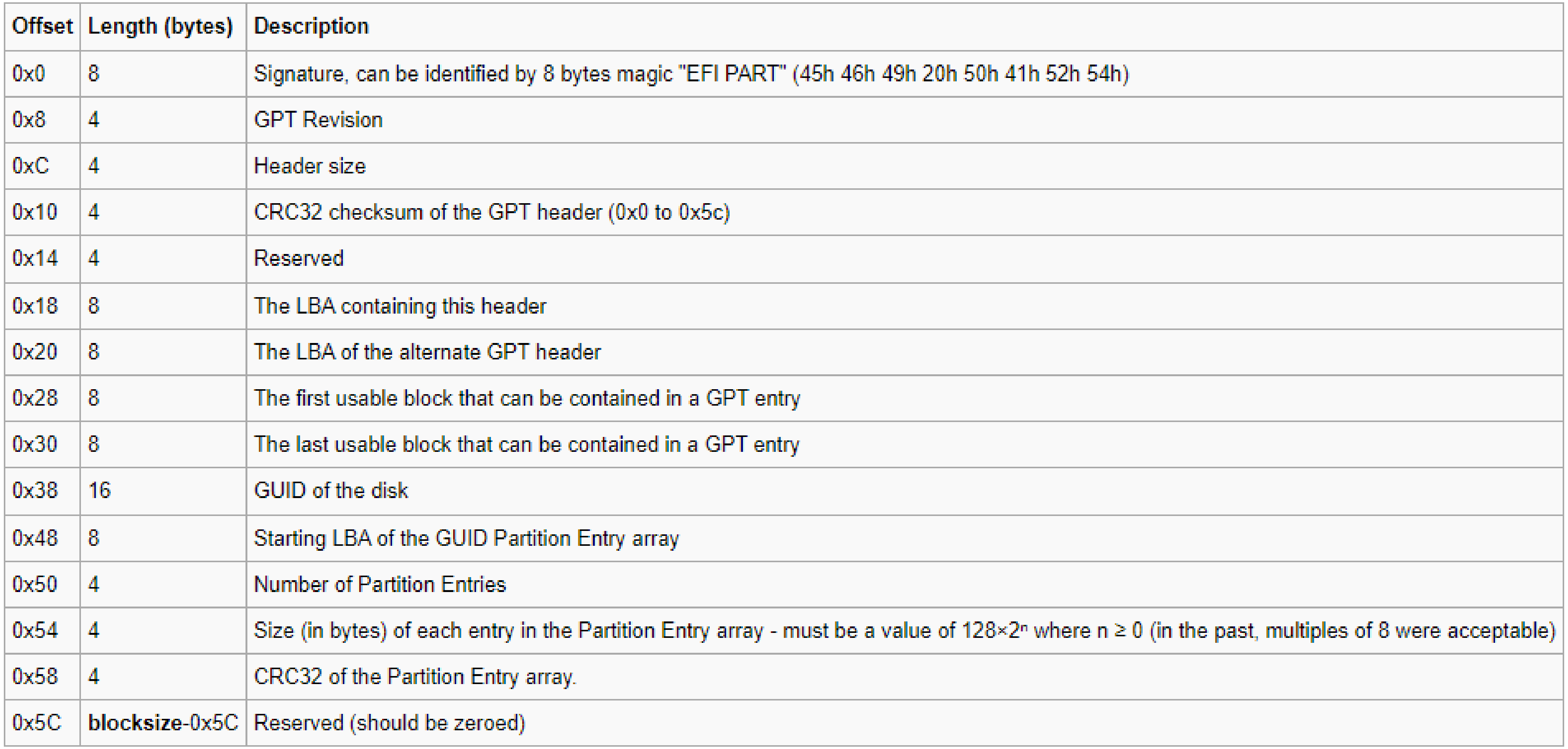
❑ GUID (Globally Unique Identifier) partition table-GPT

- ➢ The first sector is Protective MBR, which is to achieve software compatibility.
- ➢ The second sector is Primary GPT Header, which mainly defines the size and the number of the partition entries.
  - ✓ Typical size of a partition entry is 128 B.
- ➢ The next numbers of sectors contain the information of Partition Entries/Tables.
- ➢ The last part is the Secondary GPT Header, which is the copy of the Primary GPT Header.



❑ GUID (Globally Unique Identifier) partition table-GPT

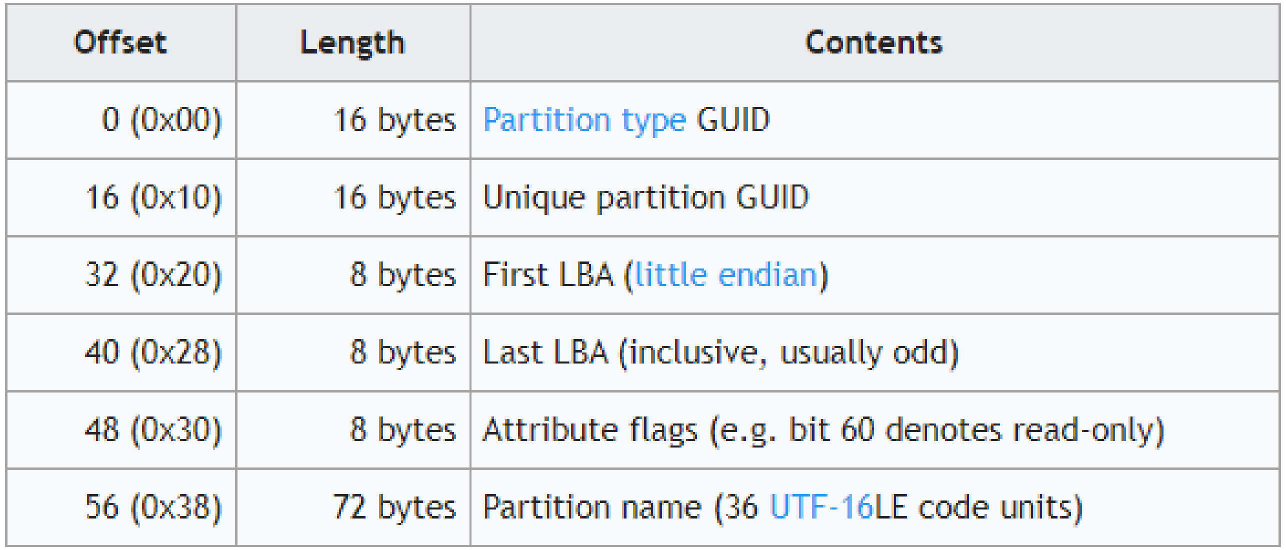
➢ LBA 1: Partition Table Header



Offset	Length (bytes)	Description
0x0	8	Signature, can be identified by 8 bytes magic "EFI PART" (45h 46h 49h 20h 50h 41h 52h 54h)
0x8	4	GPT Revision
0xC	4	Header size
0x10	4	CRC32 checksum of the GPT header (0x0 to 0x5c)
0x14	4	Reserved
0x18	8	The LBA containing this header
0x20	8	The LBA of the alternate GPT header
0x28	8	The first usable block that can be contained in a GPT entry
0x30	8	The last usable block that can be contained in a GPT entry
0x38	16	GUID of the disk
0x48	8	Starting LBA of the GUID Partition Entry array
0x50	4	Number of Partition Entries
0x54	4	Size (in bytes) of each entry in the Partition Entry array - must be a value of 128×2^n where $n \ge 0$ (in the past, multiples of 8 were acceptable)
0x58	4	CRC32 of the Partition Entry array.
0x5C	**blocksize**-0x5C	Reserved (should be zeroed)

❑ Capacity of GPT

- ➢ Given GPT partition entry (LBA 2-33) format as follow,



Offset	Length	Contents
0 (0x00)	16 bytes	Partition type GUID
16 (0x10)	16 bytes	Unique partition GUID
32 (0x20)	8 bytes	First LBA (little endian)
40 (0x28)	8 bytes	Last LBA (inclusive, usually odd)
48 (0x30)	8 bytes	Attribute flags (e.g. bit 60 denotes read-only)
56 (0x38)	72 bytes	Partition name (36 UTF-16LE code units)

- ➢ If the size of a sector is 512 Bytes, then the largest partition capacity that GPT is 2^{64} ×512 Bytes=2^{73}B=8 ZB