ECE437/CS481

INTRODUCTION TO OPERATING SYSTEM

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CONTENTS

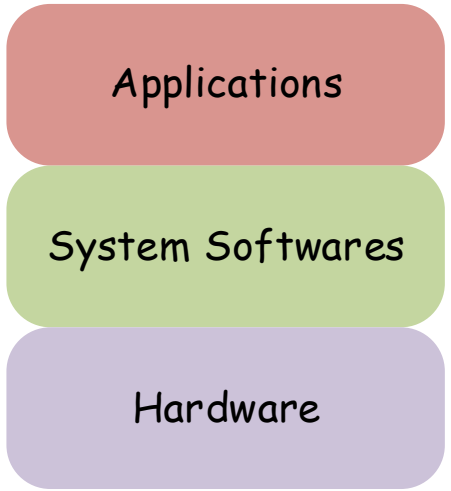
01 Concepts of Operating Systems

02 Basic Function of Operating Systems

03 Accessing Operating Systems

04 Startup Operating Systems

Concepts of Operating Systems

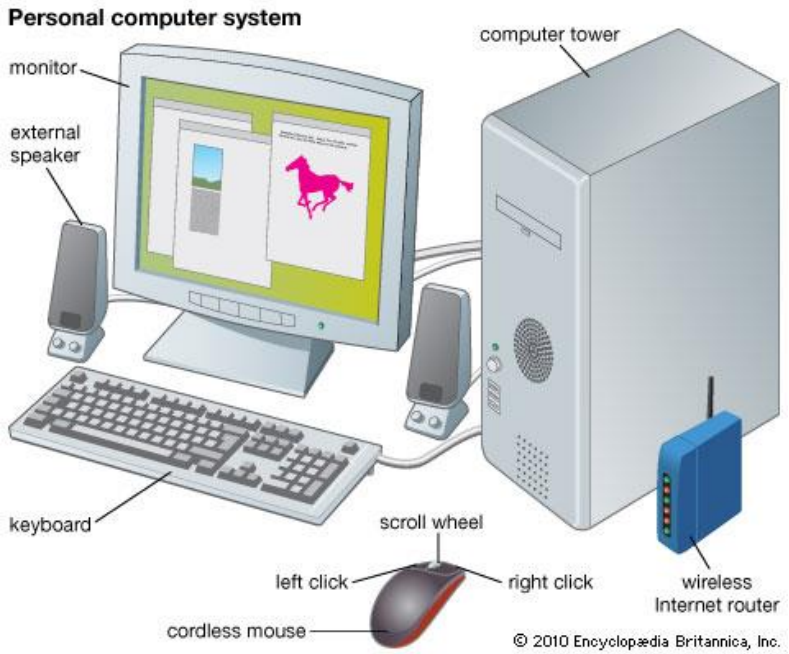


❑ Components of a computer system

- **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), Utility Software, Device Drivers, Firmware…

Concepts of Operating Systems

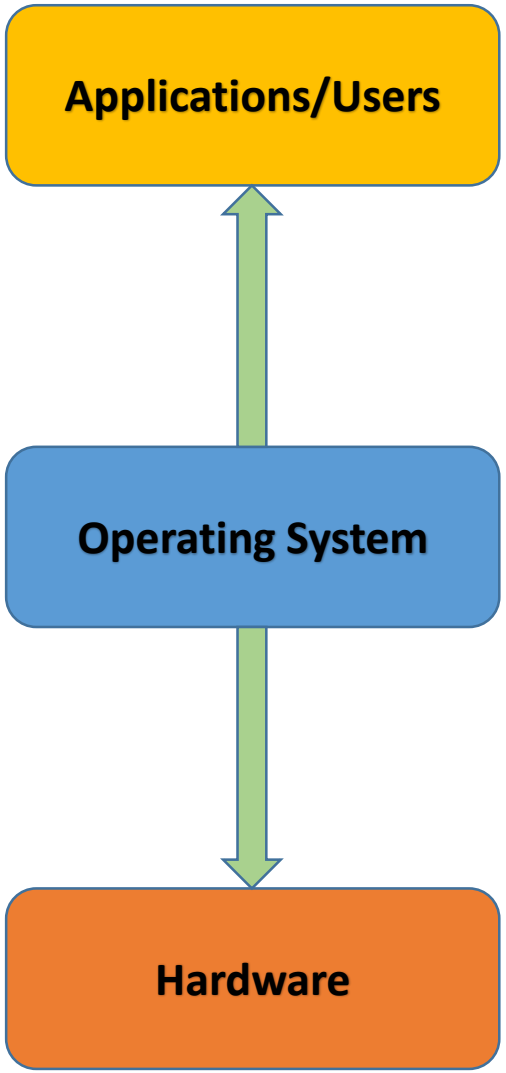
- Operating system = Important system software running at all times
  - As the 1st program to run other programs
  - A program that provides controlled access to resources.
    - ✓ CPU, Memory
    - ✓ Display, keyboard, mouse
    - ✓ Persistent storage
    - ✓ Network



- 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.

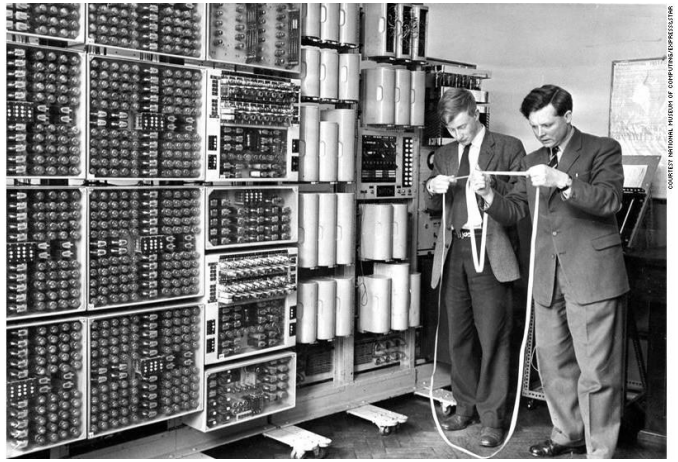
Functionalities of OS

- 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
    - ✓ Able to resolve request conflicts



Functionalities of OS

- It's not easy to make both parts happy
  - At early days, hardware resources are expensive and computers are not widely used
  - At current days, human resources are expensive and hardware become powerful



  - Key point: to make a good trade-off

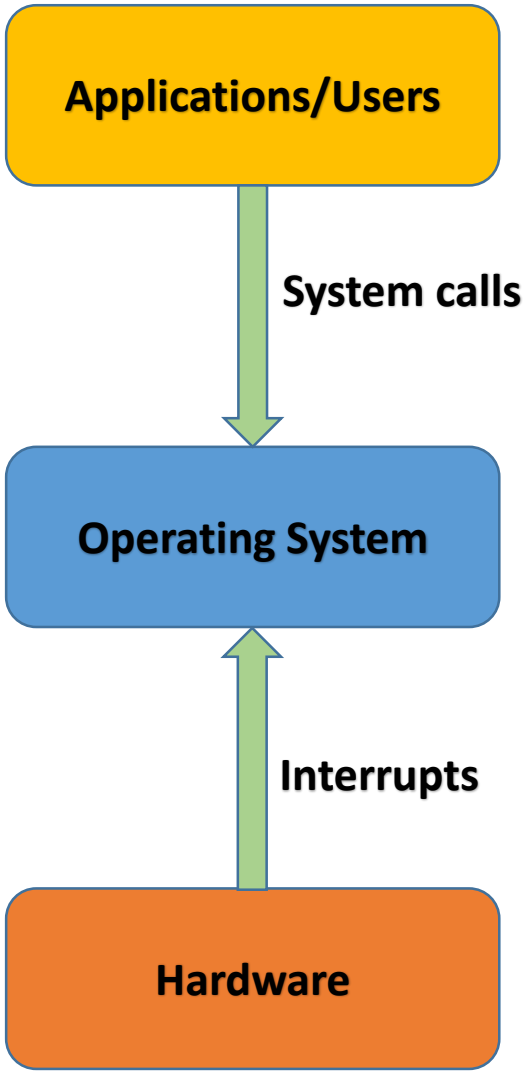
Accessing OS

From users/apps to OS

- System calls
  - ✓ Requests made to OS
  - ✓ OS process the request, may issue commands to hardware

From hardware to OS

- Interrupts
  - Event reported to OS
  - OS process the event, may issue upcalls to applications



Kernel AND OS

- The one program running at all times on the computer" is the kernel.
  - 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
    - ✓ 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 resources such as files, printers 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

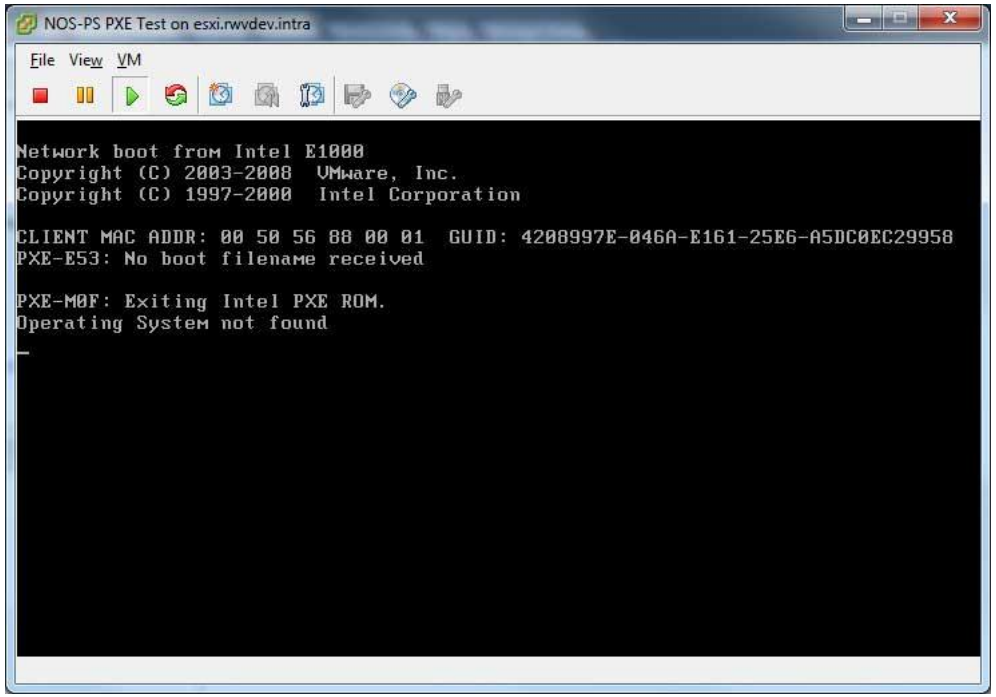
- Initial startup problem
  - CPU could only execute instructions in main memory, but main memory was volatile.
- Solution for startup
  - Transfer the boot codes (generally known as firmware, i.e., Basic Input Output System (BIOS)) into non-volatile storage to be executed.
  - **Bootstrapping**: CPU loading and processing boot codes from the non-volatile storage
  - EPROM/ROM is used as the non-volatile storage to store boot codes.
  - Note that EPROM/ROM is different from CMOS.

❑ Major Tasks of BIOS

- Power-on self-test (POST)
- Video card initialization and other devices detection
- Display start-up screen
- Brief memory test, set memory & drive parameters
- Configure Plug & Play devices: PCIe, USB, SATA
- Sequentially searching the boot device (e.g., hard disk, floppy disk, u-disk) that contains the operating system
- Load block 0 (Master Boot Record) and jump there to load the operating system

❑ 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.
  - ✓ Boot loader (446 bytes) is a program that loads an operating system.
  - ✓ Partition table (64 bytes) records partition information on local disks.
  - ✓ Magic number (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 the computer is powered on, the CPU executes the BIOS program in the EPROM/ROM.
  - The BIOS program conducts self-test, and searches for MBR in the hard disk.
  - If MBR is found, the boot loader in MBR takes over from the BIOS.
  - The binary code of OS is loaded from the hard disk into RAM.
  - OS initialize itself and takes control over all the hardware.

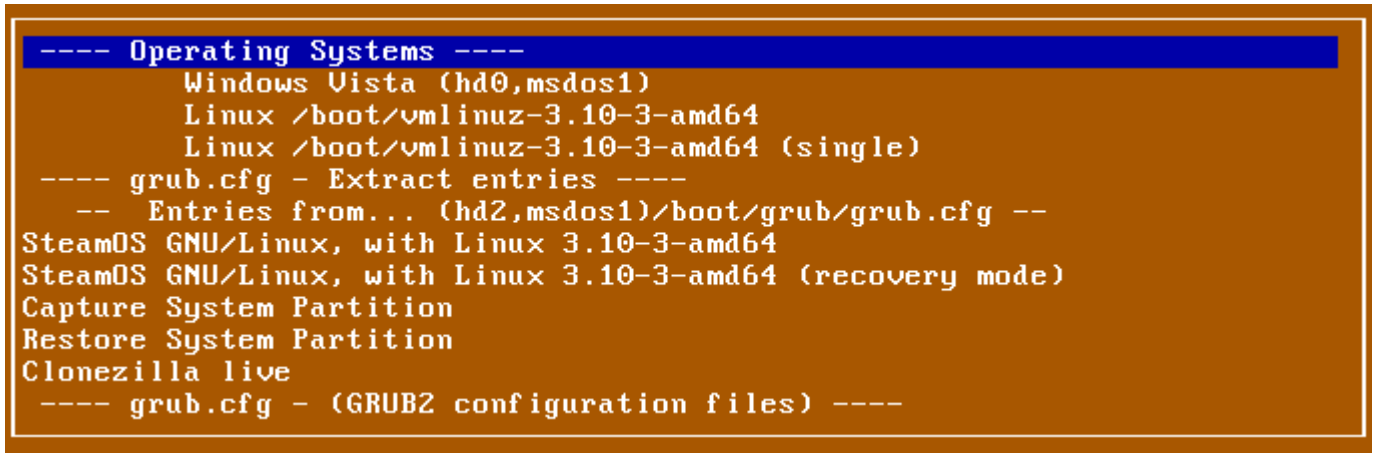
Startup Computer & OS

- How to select different OSs if the computer installs more than one OSs in different partitions?

- Multi-stage boot loader--having a boot loader load a bigger boot loader

- GRand Unified Bootloader (GRUB)--a multistage boot loader on Linux.

  - ✓ GRUB is a boot loader in MBR.
  - ✓ GRUB presents user with choice of OS's to boot.
  - ✓ GRUB loads selected kernel and run the kernel.



Startup Computer & OS

- From BIOS to UEFI, to fit to 64-bit architecture
  --UEFI (Unified Extensible Firmware Interface)

  - Both UEFI and BIOS are low-level software that starts when you boot your PC before booting your operating system. However,

  - UEFI runs faster than BIOS

    - ✓ BIOS works in 16-bit mode, limiting the amount of code that can be read and executed from the firmware ROM. UEFI can run in 32-bit or 64-bit mode, thus incurring faster bootup.
    - ✓ In BIOS, each partition can only be a maximum of 2TB in size. In UEFI, each partition could have the size to be 9.4 ZB (1e+9 TB).
    - ✓ Secure boot is a feature of UEFI that has been implemented in Windows 8.