

Introduction to Operating Systems

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Introduction

An **operating system**(OS) is a piece of software that lies between the hardware and software layer inside a computer. The OS helps the machine allocate resources to processes that require them.

The OS allocates resources to different processes on a computer.

Computer System Organization

When we have an I/O request, the device controller will receive a signal to load and move the data to the CPU or main memory. When this process is done, the controller will send a signal to the CPU informing of a successful completion of the transfer.

There are wother ways of triggering a system interrupt. Sometimes the program might create an interrupt, known as a **software interrupt**. Other times, the hardware itself might create an interrupt. When this happens, there is a wire connected to the CPU which is directly activated.

There are a couple useful distinctions:

- Random Access: This type of memory allows any part of its data to be accessed without having to first access the other parts. This memory is *volatile*, which means it will be wiped clean next time the computers boot.
- Solid State: A solid state drive(SSD) uses solid state technology and removes any moving components from the drive. This allows for faster read speeds since we don't have to wait for the platter to spin in the correct decision under the read/write head.

Computer System Architecture

In days past, the comptuer was able to run on a single **core**, which executed a general instruciton set needed by application programs. There could also be some smaller and different processors such as **controllers**.¹

However, recently there are multicore systems, which have more than one physical core. This means that they can execute more than one instruction at at a time. However, it depends on whether there

¹ A **controller** is a type of device which handles taking information from I/O devices and getting it to the CPU. A controller usually has its own buffer, where it stores the data it is responsible for fetching before sending it to memory or CPU.

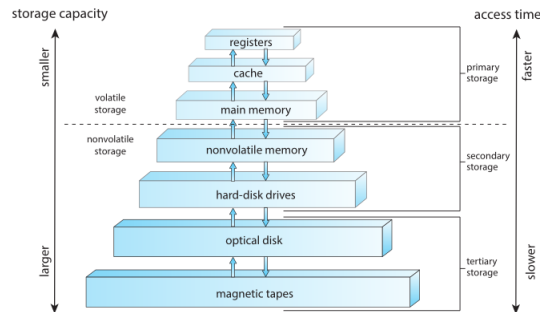


Figure 1: Memory hierarchy. As the speed of the memory increases, so does its cost. So we can only include a limited amount of very quick memory. Cache and registers usually are very limited and are located directly in the CPU.

are any resources to allocate available. These systems will usually share L2 cache, but L1 is local for each core. Since there will be N individual CPUs according to the computer, application programmers should effectively use all the cores.

Why does continually adding more CPU cores not work *ad infinitum*? There is an overhead performance penalty when trying to coordinate their loading. Also, once we add too many CPUs, the competition for the system bus might bottleneck performance.

Blade servers usually have multiple machines on the same chassis. **Clustered systems** are usually independent computers that share mostly storage. They might be individual multicore systems that are interconnected to share storage. Clustered systems are usually used in systems where we need the maximum reliability. The advantage of having clustered systems is that we can monitor the performance of the other nodes. We can assign one node in the cluster to monitor another one of the nodes. If the observed node fails, we can set the monitoring node to take over the failed node's operation, and report the error.

Some other types of networks might run on wide-area-networks and thus require to be connected over many miles. Software such as Oracle's database system might run on every node in the network, as well as have a layer of software controlling other aspects of resource allocation.

Operating System Operations

The first step the Operating System is responsible for is initializing the programs that will run on the user's computer. First, we load a **bootstrap** program, which is in charge of loading the operating system into memory.

The kernel then runs and initializes I/O and starts other daemons. If there is nothing happening at the moment, then we wait for certain **interrupts**, which are the hardware's way of signalling events. When a certain program is being executed, it is called a **process**. The CPU

has several programs in main memory at a given time, which leads to a better utilization of the CPU. This is because the CPU might finish a program and will have to wait while the next one is loaded into memory. Also, the CPU might be idle while waiting for an I/O operation. If the CPU did not have another program to execute in the meantime, the CPU would idle.

Dual-Mode Operation

We also need to differentiate between user programs that are executing and actual OS code that is running. We need this to ensure that malicious user programs cannot affect the way the OS runs. The two modes are: **user mode** and **kernel mode**. We distinguish them by using a **mode bit** directly in the hardware. When the OS first loads, it does so in kernel mode, and when it's time to execute a user program, we switch the bit to user mode.

Resource Management

We remember that the OS is the main resource manager in a system. This means that when a process requires some memory resources, the CPU will allocate those resources and then reclaim them when the process is over.

Memory management requires us to efficiently use the main memory. When a program is executed, it first has to be loaded into main memory. It uses a direct address to fetch the instruction to execute next. The OS can decide when the information needs to move in and out of main memory and how much space the process requires.

The computer stores information in a the basic logical storage unit called a **file**. Files are then stored on secondary and tertiary storage, and can take either textual or binary form.

Another important aspect of operating systems is how we store the files on the disks. Some important things to do with files and storage are:

- **Mounting:** Making filesystems available on the user's computer.
- **Free-Space Management:** The OS has to keep track of how empty the disk is and how much space we have left, hence we have to keep track of many file sizes.

Secondary and tertiary storage can be used for storage in a hard-drive disk or SSD on the computer, or even for some archival storage.

Virtualization

Virtualization allows us to run programs meant for one environment on another piece of hardware. for example, I could have a software layer that tries to mimic other OS. **Emulation** refers to the times when the source and target CPU are different and the program is not compiled to the native code.

With a virtual machine, we can let the host system act as if it's running an entirely different system, with no need to recompile. We might use this technology when developing for multiple OSes. We don't need to buy an entire different system if we use a VMM.