Introduction to OS (cs1550)

- Why take this class? Why with Mosse?
  - it's mandatory
  - it's a great class
  - it's a great prof
  - it's easy (NOT!!!! do not fool thyself!)
  - it's good for you
- Life is not life anymore while this class is going on. Be careful! Specially if you're taking also compilers or some other hard programming class…

Class Outline

- Book: Tanenbaum's Modern OSs
- Intro to OSs (including Real-Time OSs)
- Processes (definition, synchronization, management)
- Memory (virtual memory, memory allocation)
- IO (disks, sensors, actuators, keyboards, etc)
- InterProcess Communication (networking, data transmission, etc)
- Fault Tolerance, Real-Time and Security (time permitting)

Operating Systems

- Manages different resources (CPU, mem, disk, etc)
- Improves performance (response time, throughput, etc)
- Allows portability, enables easier programming (no need to know what the underlying hardware)
- Interface between the hardware and the rest of the machine… editors, compilers, user programs, etc
- Standard interface is typically done in two ways:
  - system calls: control goes to the **Operating System**
  - library calls: control remains with the **User**

Brief History

- First Generation of computers had no OS: **single-user**. All coding done directly in machine language, memory resident code (no other resources to manage)
- Second Generation has basic OS: **batch processing**. Read input (tape/cards), process, output to tape or print
- Third Generation improved life: **multiprogramming!** Careful partitioning of memory space (4-12KB), drums and disks added for reading cards and spooling outputs (**S**imultaneous **P**eripherals **O**perations **O**n-**L**ine)
- **Time-sharing** created several *virtual machines*

History (cont)

- Fourth Generation: **PCs** and **workstations**. Cheaper, faster, more user-friendly (Thank Macs for interfaces!)
- UNIX precursor MULTICS (MULTIplexed Information and Computing Services) was the first "modern" OS. Bell+MIT+GE (MULTICS --> units --> Unix)
- Berkeley improved on it: paging, virtual memory, file systems, signals (interrupts), networking!

Networking!

- **Networked OS**s are connected through a network, but user needs to know the name/type/location of everything
- **Distributed OS**s (e.g., Amoeba, Mach, Locus) provide transparency to user, yielding one huge virtual machine!
- **Specialized OS**s are built for specific purposes: routing engines (Networking), lisp machines (AI), time constrained applications (Real-Time), Internet (WWW servers), massively parallel uses (supercomputers), etc
- All these are coming together, hard to identify boundaries anymore.

Microsoft World

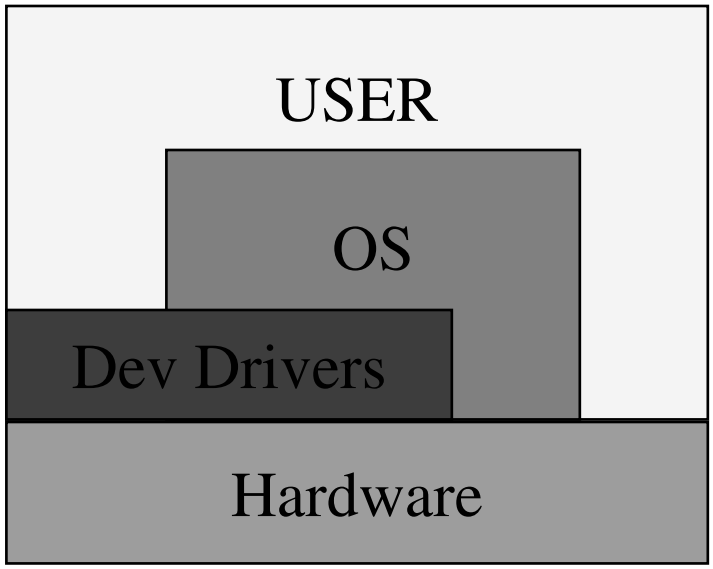
- Excellent marketing, some good products
- OSs started with DOS (Disk OS), no nothing, just very simple commands!
- Windows 3.1 was a huge jump (based on decades-old technology initially developed at Xerox then Macs)
- Windows 95 (released in 96) improved tremendously the state-of-the-affairs for MS, but still unreliable
- Windows NT *approaches* Unix distributions, with more user-friendly interface.

Unix World

- Created at AT&T, re-written/improved by Berkeley
- ATT had majority control and good support (reliable OS)
- OSF (Open SW Foundation, now Open Group) is a consortium of several companies to standardize UNIX
- Different subgroups (syscalls, shells, RT, etc)
- Standardization is with respect to interfaces and not implementation of primitives. Impln is left to the implr
- Modern applications are time constrained (tel, video, etc)
- Real-Time playing an increasingly important role

OS Structure

- Interface can be done at any level (depends on level of security of OS)
- Interface with the lower level layer gets translated
- Machine dependent language used for accessing hardware



- Main advantage of direct resource access is efficiency
- Main advantage of indirect access is portability
- Completely layered OS? Why or why not?

OS Functions

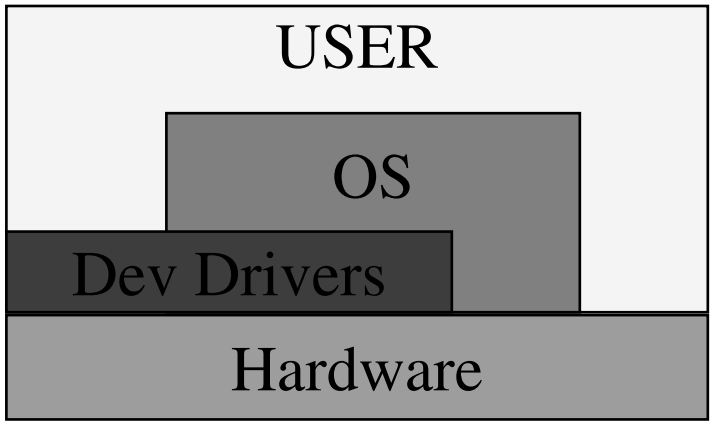
- Controls and manages resources (disks, memory, CPU, …); sends/receives control commands and data
- Allows multiprogramming (several programs “at the same time” in the same resource)
- Carries out communication between processes (inter and intra processor)
- Manages interrupt handlers for HW and SW interrupts
- Provides protection and security to processes
- Prioritizes requests and manages multiple resources in a single machine (eg multiprocessors or CPU IO reqs)

OS Functions

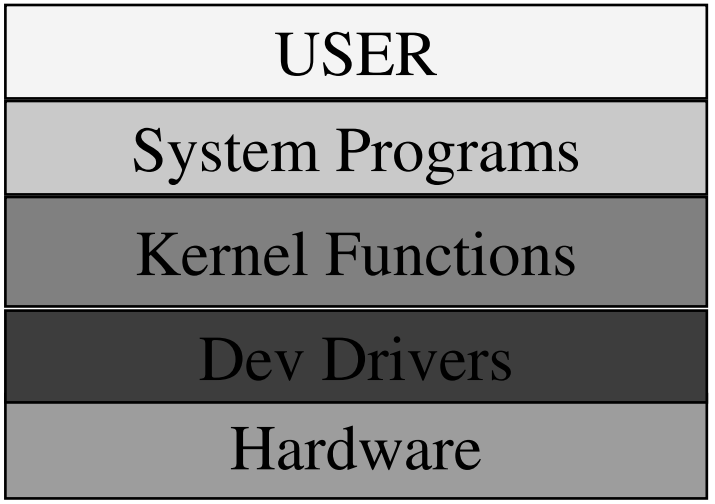
- OS manages resources, including management of
  - processes (creation, deletion, suspension, comm, synch)
  - main memory (usage, alloc/de-alloc, which processes get it)
  - 2ary storage (disk scheduling, alloc/de-alloc, swapping, files)
  - IO interfaces and devices (eg, keyboard, caching, memory)
  - protection (authorization, file and memory protection, etc)
  - InterProcess Communication (intra- and inter-machines)
  - Command interpretation (shells to Xlate user to OS). Typically includes the user interface that the OS uses.

OS Structure

- Hardware at the bottom layer
- Accessing the lower layer thru the higher layers
- DOS programs can access HW
- Unix has controllers and dev drivers (DD) controlling devices
- *system calls* are the interface between user and OS (DDs)
- *libraries* and *system programs* invoke sys_calls



Typical DOS



Typical Unix

OS Structure

- Interface can be done at any level (depends on security)
- Machine dependent language used for accessing HW
- Main advantage of direct resource access is efficiency (less layers means less overhead, ie, better performance
- Main advantage of indirect access (*syscall*) is portability
- Modular approaches (ind access) have less flexibility, since appls only access HW thru libraries and sys_calls
- Layering means that one level is defined in terms of the level below (level *0* is the HW, level *n* is the user appls)

Modular Approach

- Create well-defined interfaces between any two layers
- Create well-defined properties of each layer
- Attempt to decrease the number of layers to improve efficiency and performance
- The final goal is to make the OS flexible and efficient
- Create the layers such that each user *perceives* the machine as belonging solely to himself or herself
- This is the concept of a **virtual machine**, which allows each user to avoid thinking about others' processes

Language

- System calls are the interface between user and OS
- Access to the resources is done through priviledged instructions (for protection)
- User applications cannot execute in kernel mode
- User applications user libraries that invoke sys_calls
- System procedures are executed to access resources, via priviledged instructions (called from sys_calls)
- This way, no process can influence other executions, on purpose or by accident: resource protection
- Example: accounting, priority information

Language (cont)

- System calls can be divided into 5 categories:
  - process control
  - file manipulation
  - device manipulation
  - infomation maintenance
  - communication
- Special purpose OSs can also have special primitives:
  - specification of deadlines, priorities, periodicity of processes
  - specification of precedence constraints and/or synchronization among processes

Language (cont)

- Examples of libraries are language constructs to carry out formatted printing
- Examples of sys_calls are primitives to create a process
- For example, *the reading of 10 bytes of a file*:
  - The user does *fscanf*, the kernel requests a block of bytes from the device driver (DD), which talks to the controller of the disk to obtain a block of data. The block is transfered into a buffer, in the kernel address space. The kernel then picks the 10 bytes and copies them into the user-specified location. This way, the kernel accesses kernel and user space, but the user only accesses user space!

System Programs

- System programs do not interact directly with running user programs, but define a better environmnt for the development of application programs.
- Sys programs include: compilers, file manipulation and modification, editors, linker/loaders, etc
- An important one is the *command interpreter* (or shell), which parses user input, interprets it, and executes it
- Shells can either execute the command, or invoke other system programs or system calls to do it.
- Trade-offs: performance, increasing/updating # of commands

More on Languages

- Different process types have different requirements
- Different requirements beg for different languages
- Assembly, Lisp, Prolog, Java, RT-C, etc.
- Real-time languages inform the OS about its needs in order to enhance the predictability of its execution
  - deadline of a thread (by when do I need this done)
  - period of a thread (what is the frequency of this task?)
  - resources to be used (amount of memory or semaphores)
  - precedence constraints (door must be open for a robot to exit)