CSCI-GA.2250-001

Operating Systems

Lecture 1: Introduction

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Who Am I?

- Mohamed Zahran (aka Z)
- Computer architecture/OS/Compilers Interaction
- http://www.mzahran.com
- Office hours: Mon 3:00-5:00 pm
- Room: WWH 320

Formal Goals of This Course

- What exactly is an operating systems?
- How does the OS interact with the hardware and other software applications?
- Main concepts of an OS
- OS in many contexts

Informal Goals of This Course

- To get more than an *A*
- To learn OS and enjoy it
- To use what you have learned in *MANY* different contexts
- To be able to develop your own OS if you want to
- To start your research project in OS

The Course Web Page

http://cs.nyu.edu/courses/spring13/CSCI-GA.2250-001/index.html

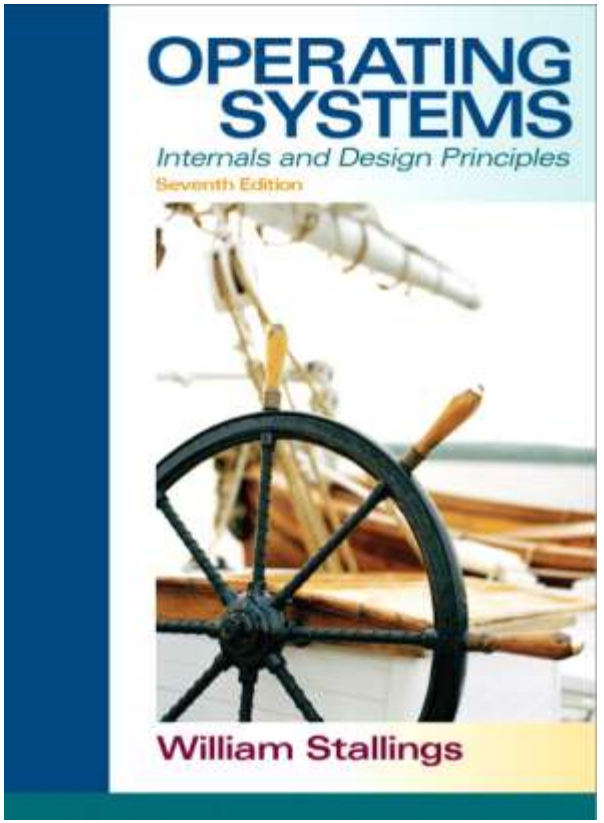
- Lecture slides
- Info about mailing list, labs, … .
- Useful links (manuals, tools, …)

The Textbook

Operating Systems: Internals and Design 7/E

William Stallings

ISBN-10: 013230998X



Grading

- Homework : 10%
- Lab : 30%
- Midterm : 25%
- Final : 35%

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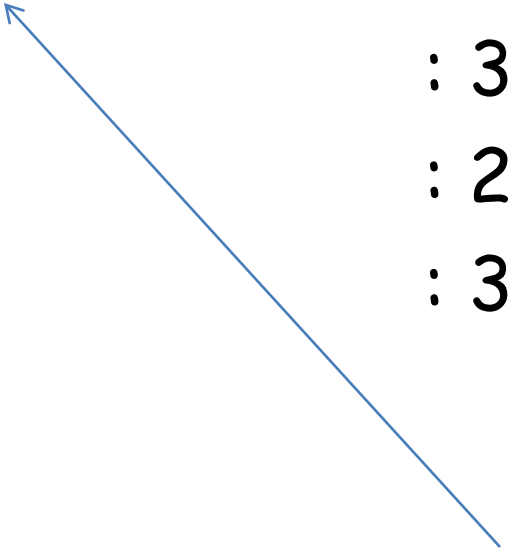

- Due at the beginning of the lecture
- In hardcopy
- Will be graded and returned to you
- No late submissions accepted

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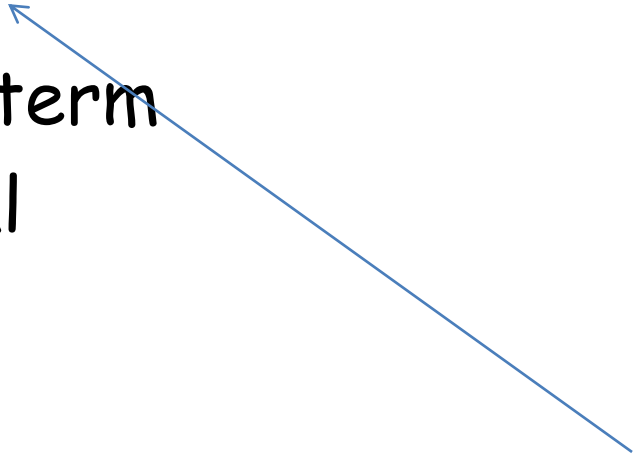

- Usually due few weeks after assignment
- Submitted as softcopy
- 1 point penalty per day late

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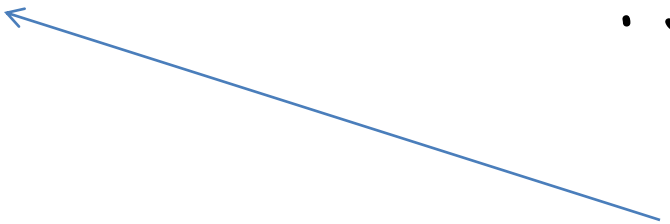


- Cumulative
- Open book/notes
- No electronic equipment

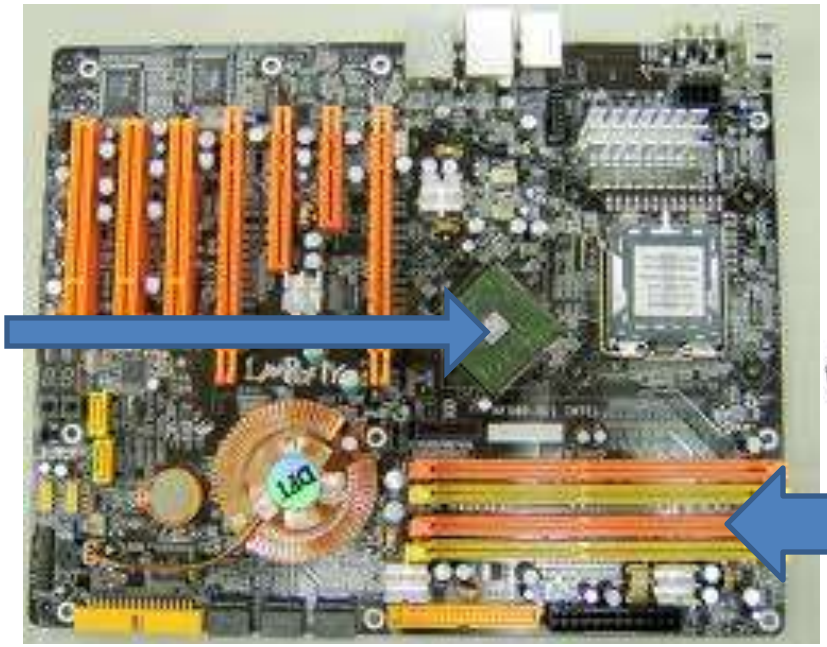
Integrity

- Academic integrity
- http://www.nyu.edu/about/policies-guidelines-compliance/policies-and-guidelines/academic-integrity-for-students-at-nyu.html

- Your homework, labs, and exams must be your own - we have a zero tolerance policy towards cheating of any kind and any student who cheats will get a failing grade in the course.

- Both the cheater and the student who aided the cheater will be held responsible for the cheating


intel
Core™ i7




Blue Bay

Media Player

emails

Games

Word Processing

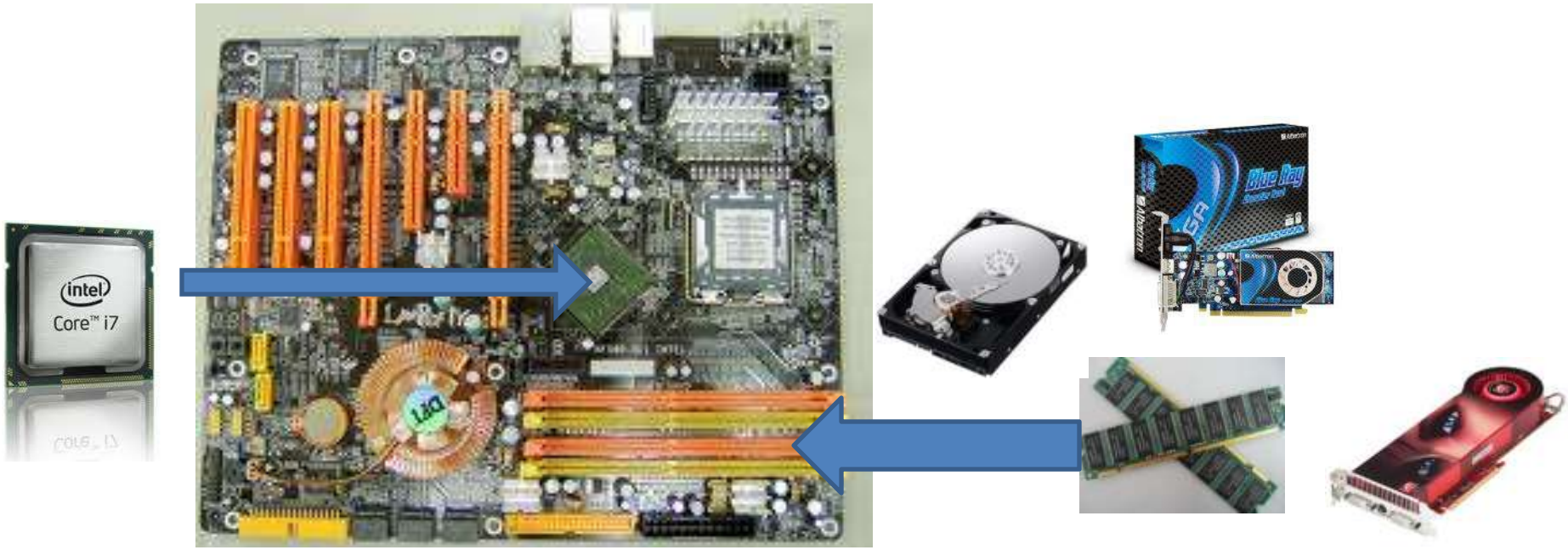
Media Player

emails

Games

Word Processing

Does a programmer need to understand all this hardware in order to write these software programs?



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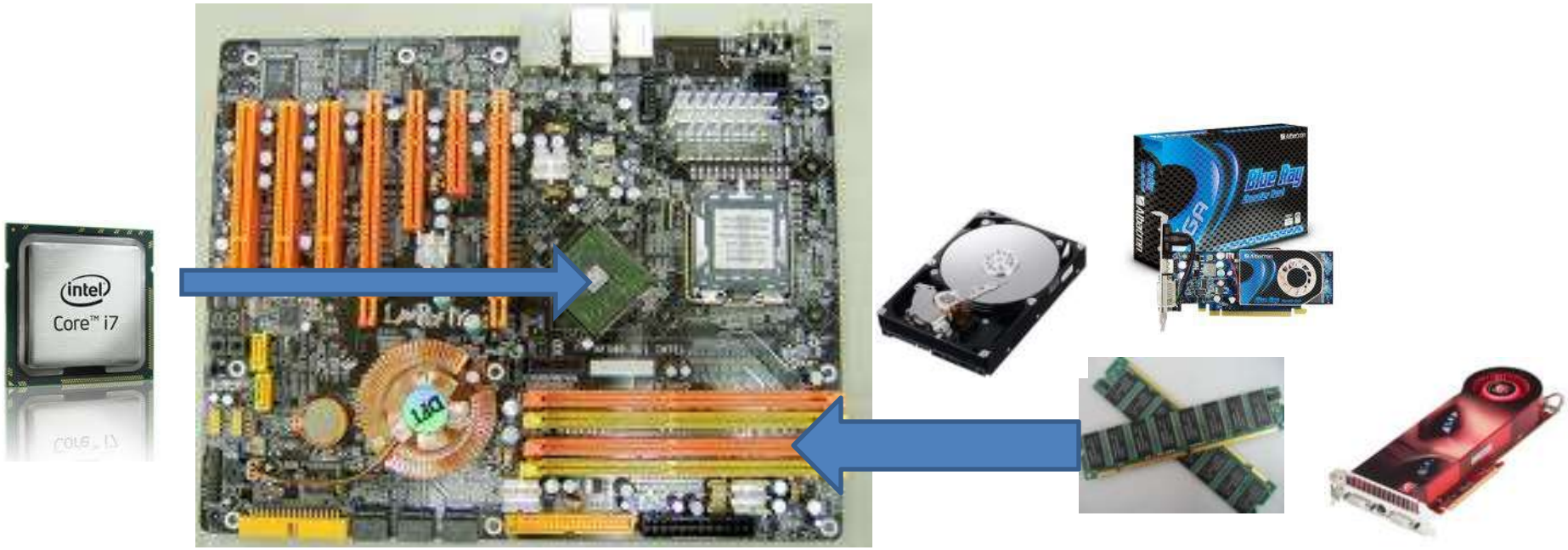
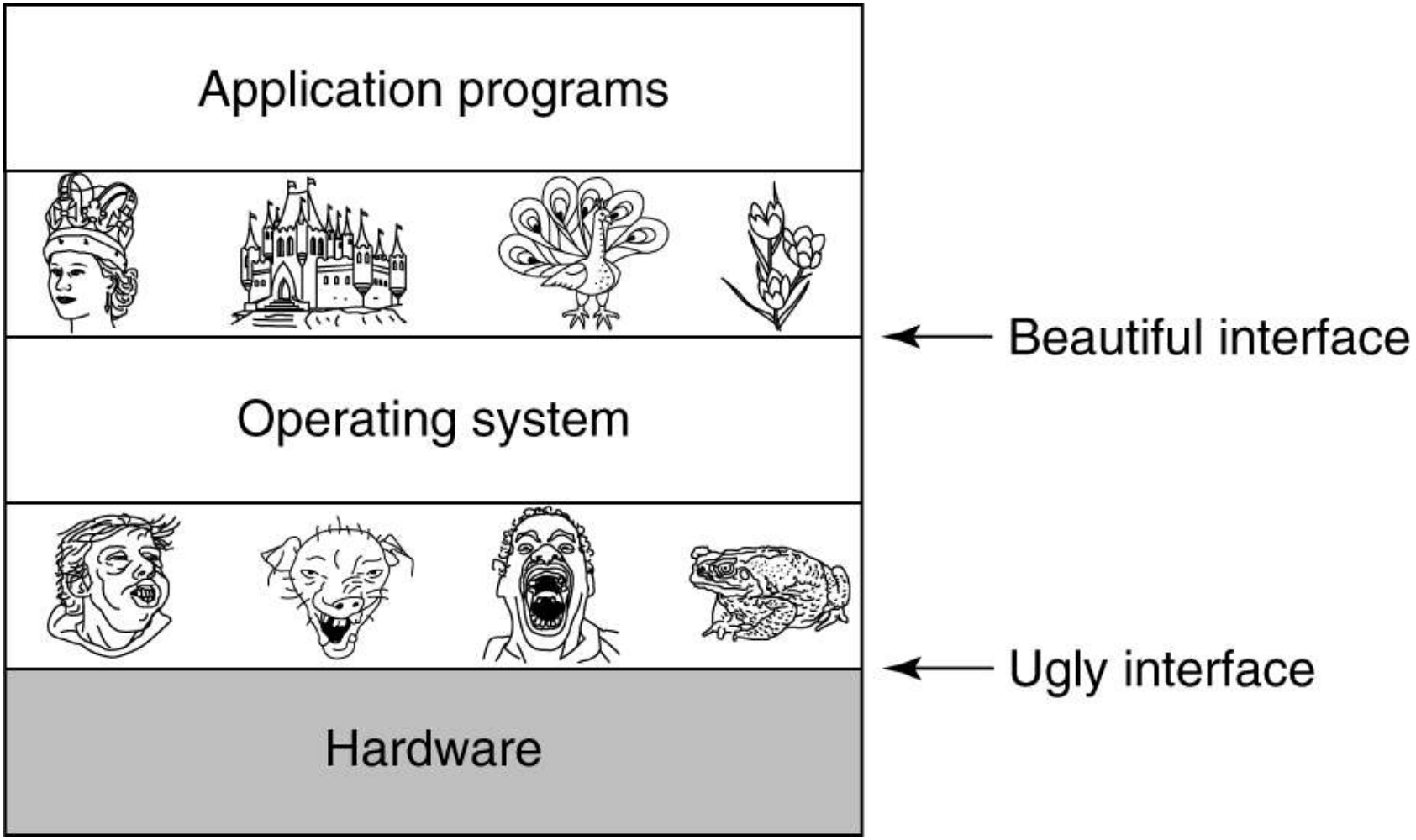
Operating System



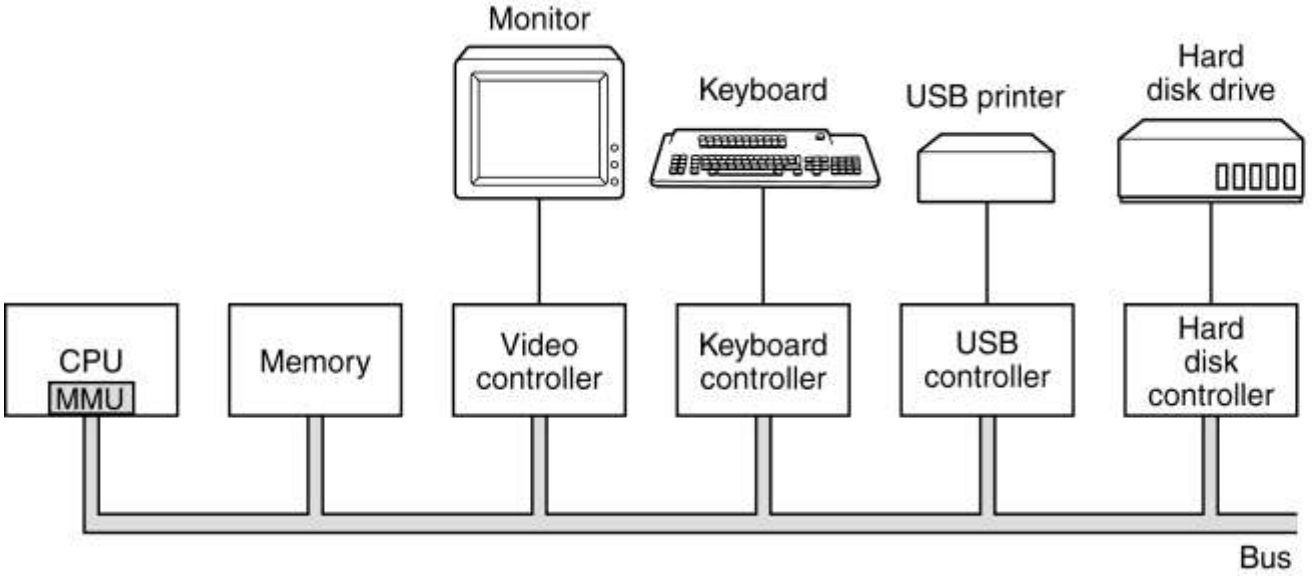
The Two Main Tasks of OS

- Provide programmers (and programs) a clean abstract set of resources

- Manage the hardware resources


Application programs
Operating system
Hardware
Beautiful interface
Ugly interface

A Glimpse on Hardware



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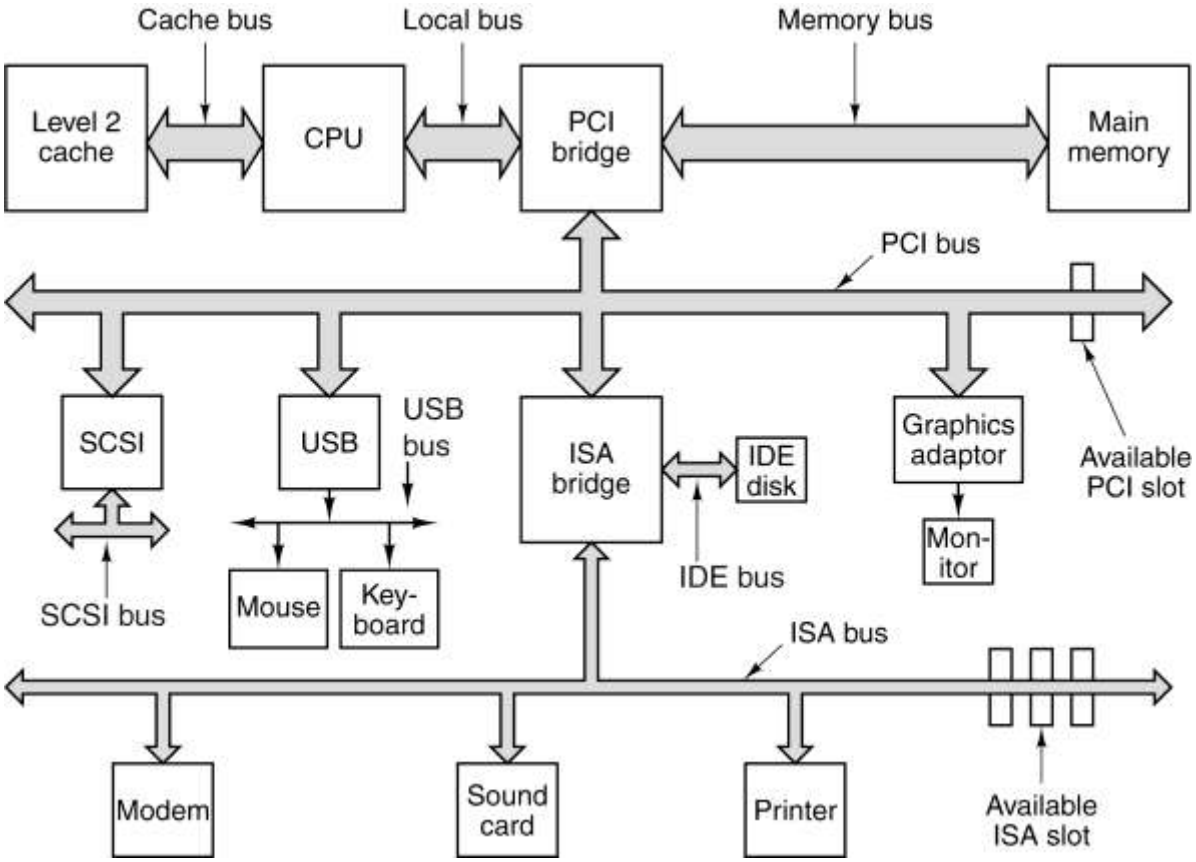
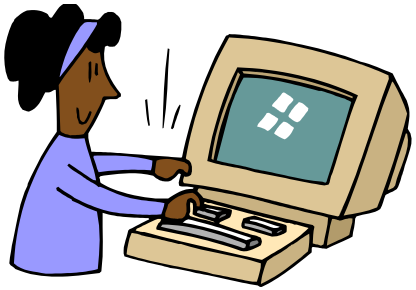


Basic Elements

Processor(s)

I/O Modules



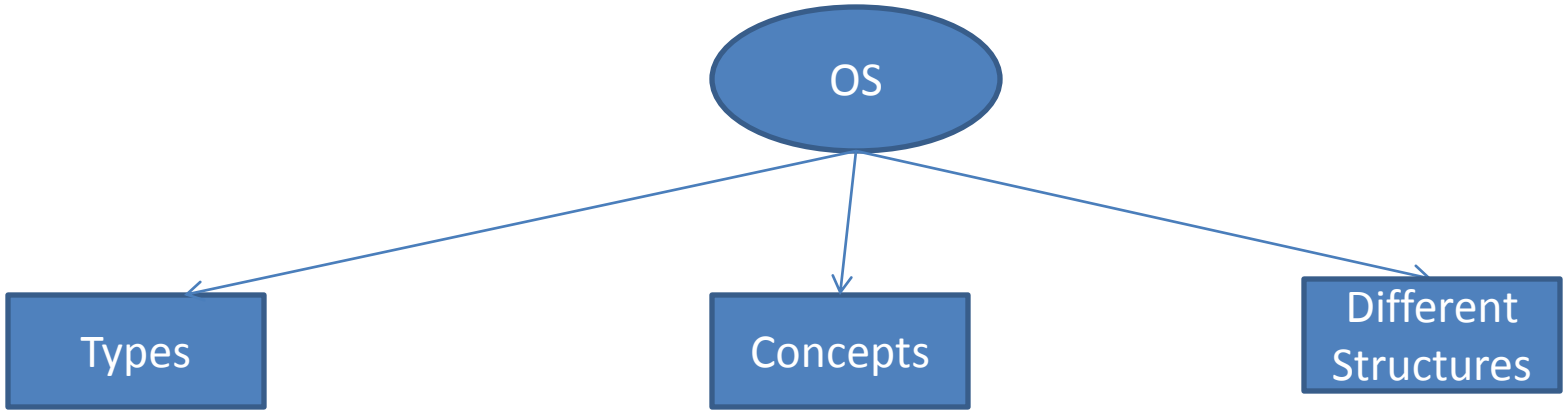
Main Memory

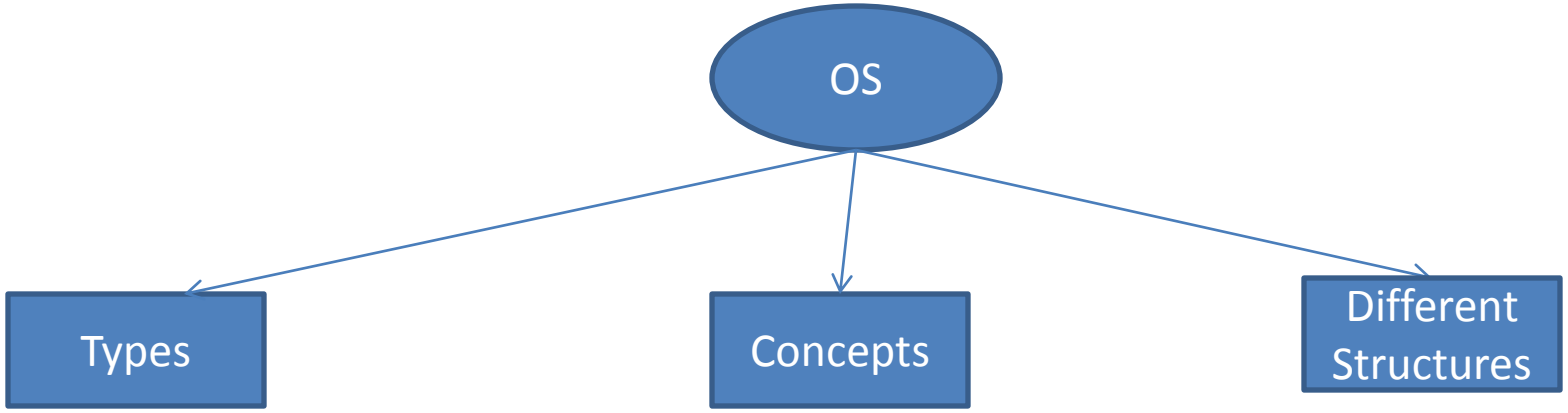
System Bus

Booting Sequence

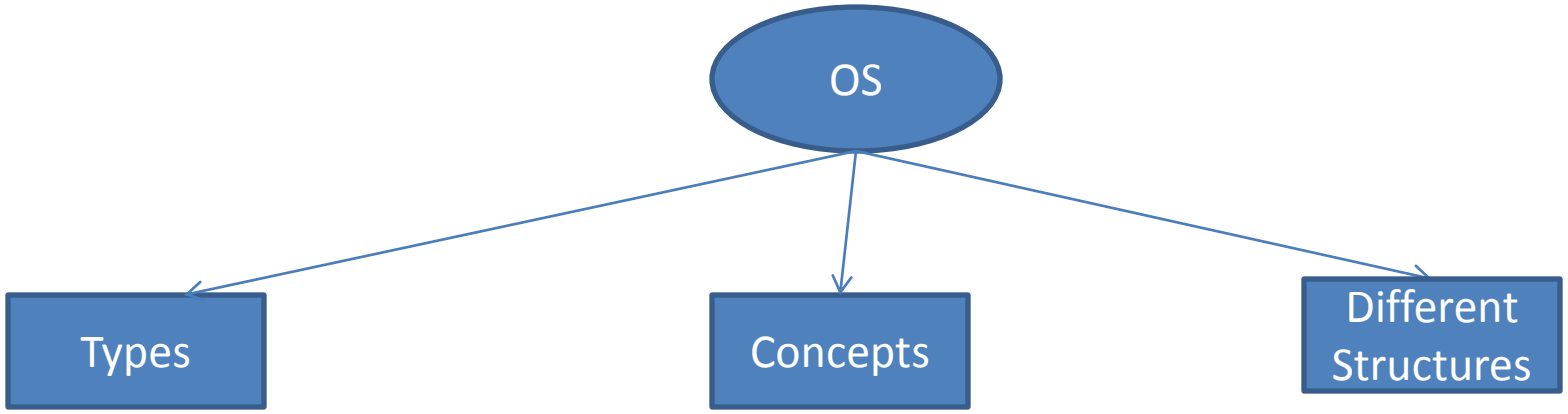
- BIOS starts
  - checks how much RAM
  - keyboard
  - other basic devices

  } **POST (Power On Self Test)**
- BIOS determines boot Device
- The first sector in boot device is read into memory and executed to determine active partition
- Secondary boot loader is loaded from that partition.
- This loaders loads the OS from the active partition and starts it.


OS
Types
Concepts
Different Structures



- **Mainframe/supercomputer OS**
  - **batch**
  - **transaction processing**
  - **timesharing**
  - **e.g. OS/390**
- **Server OS**
- **Multiprocessor OS**
- **PC OS**
- **Embedded OS**
- **Sensor node OS**
- **RTOS**
- **Smart card OS**



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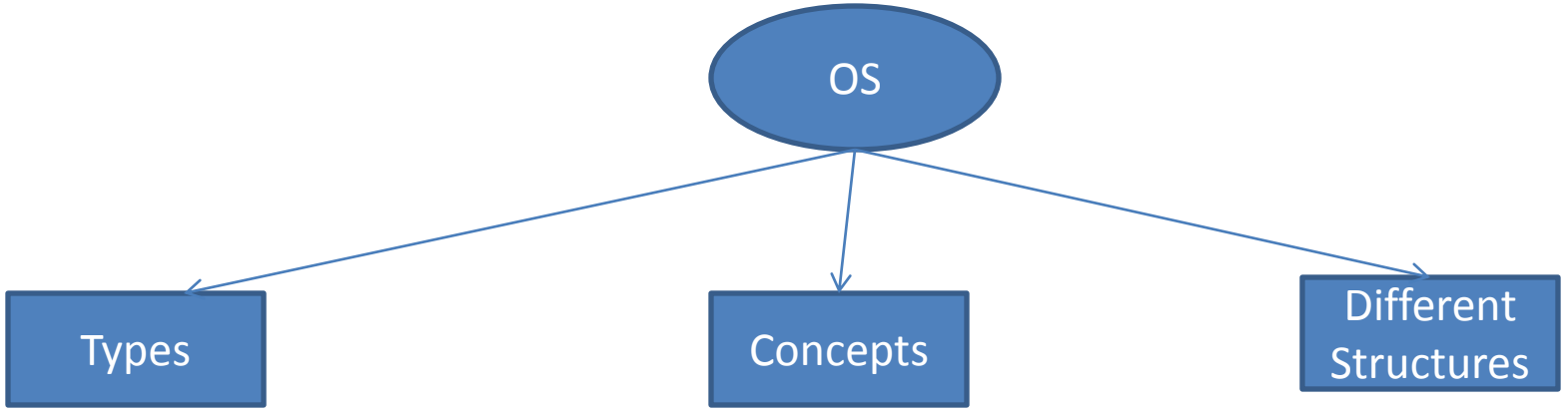
- **Processes**
  - **Its address space**
  - **Its resources**
  - **Process table**
- **Address space**
- **File system**
- **I/O**
- **Protection**



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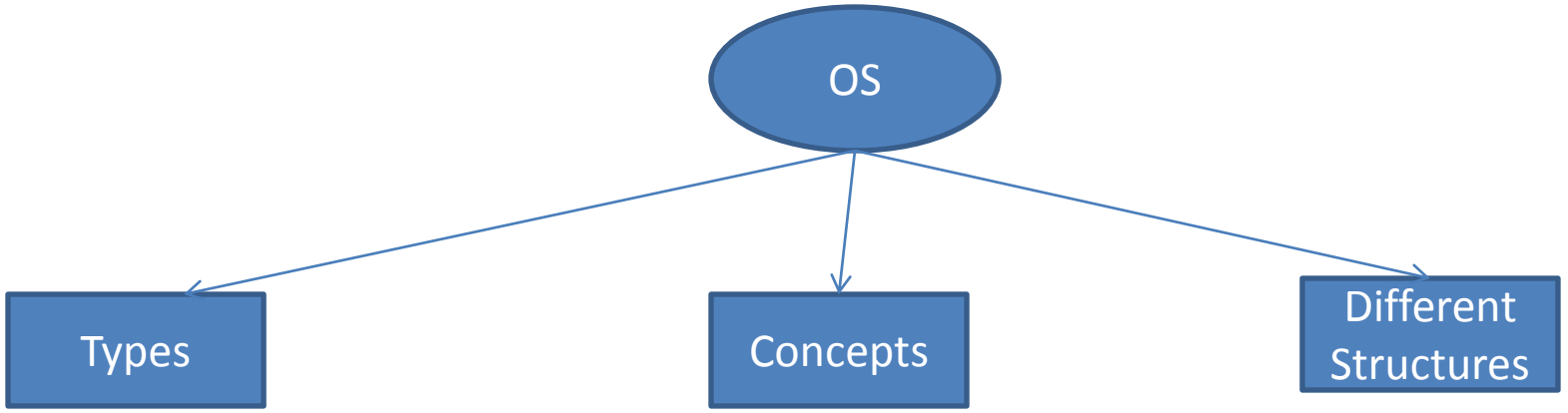
- **Monolithic**
- **Layered systems**
- **Microkernels**
- **Client-server**
- **Virtual machines**



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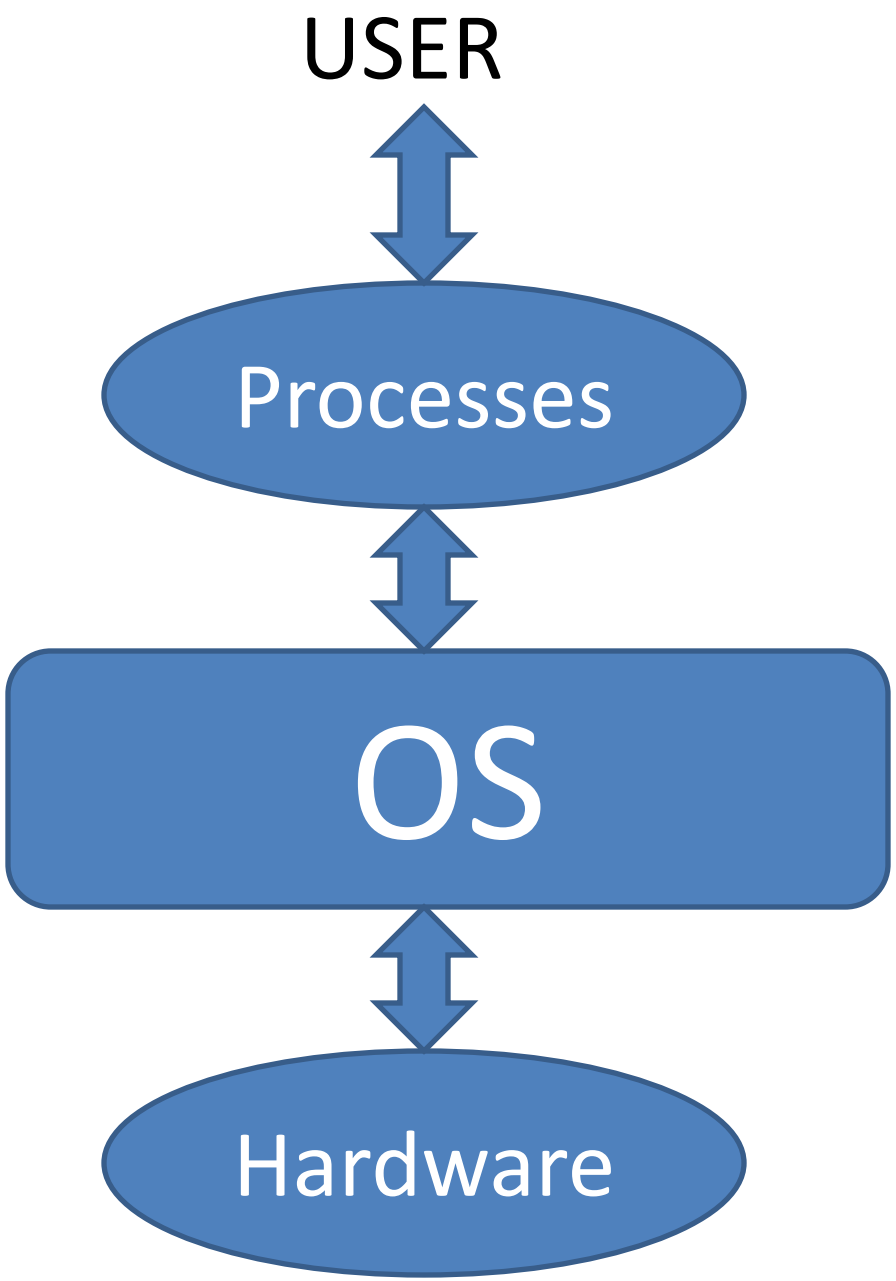
Main objectives of an OS:

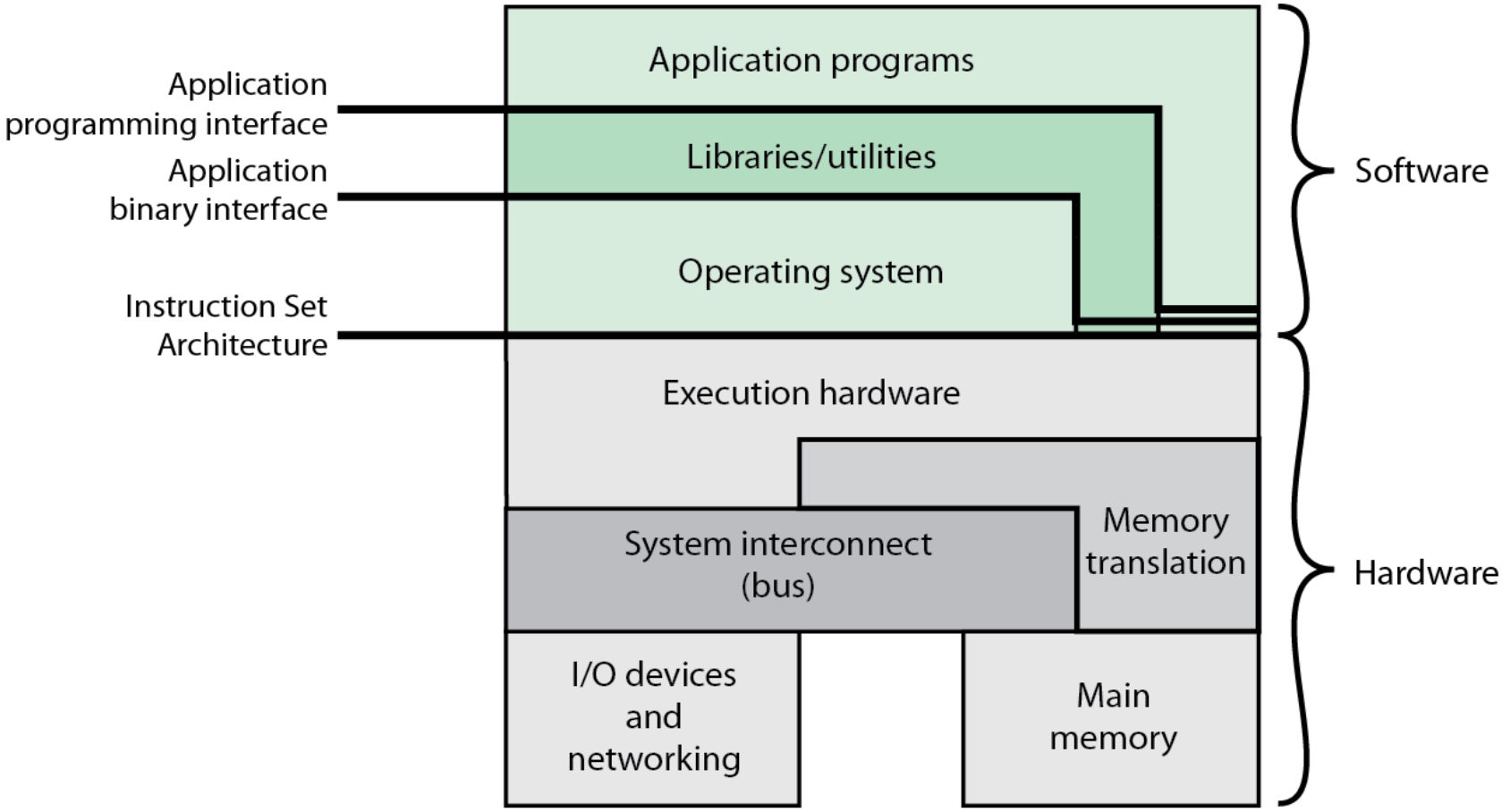
- Convenience
- Efficiency
- Ability to evolve


USER
Processes
OS
Hardware

OS Services

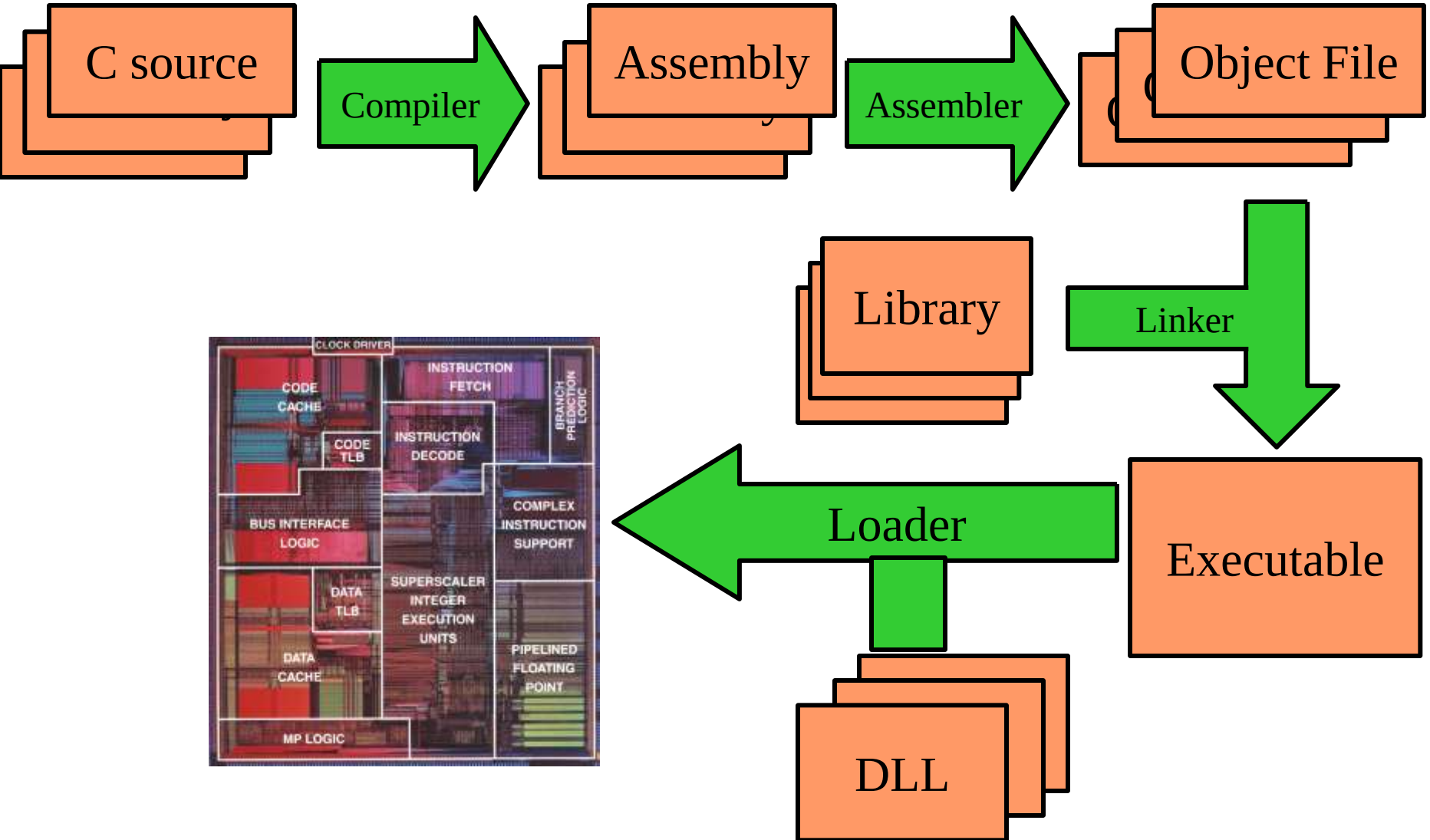
- Program development
- Program execution
- Access I/O devices
- Controlled access to files
- System access
- Error detection and response
- Accounting

Hardware and Software Infrastructure



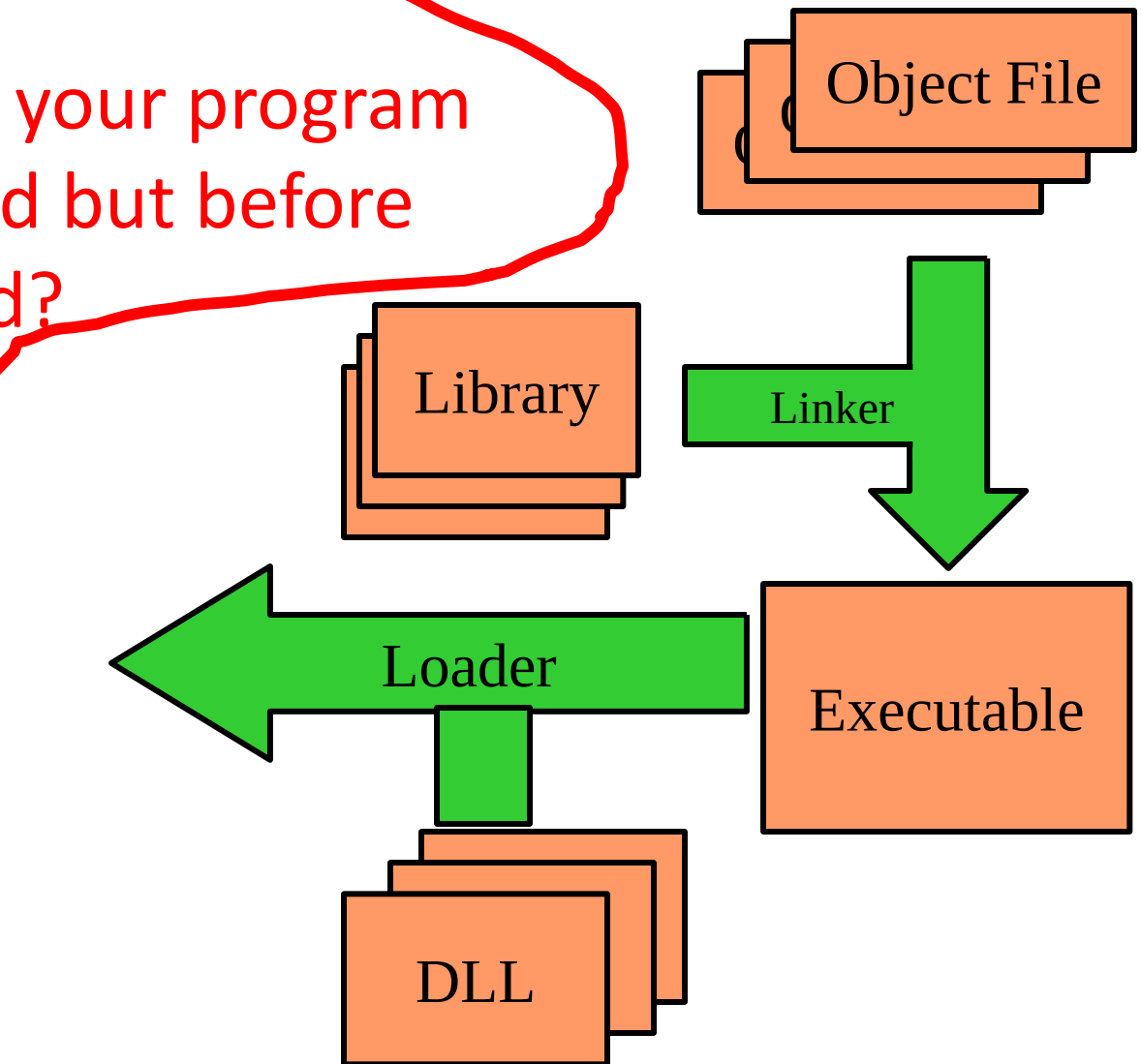
Computer Hardware and Software Infrastructure

Source Code to Execution



Source Code to Execution

What happens to your program after it is compiled but before it can be executed?



The OS Expectation

- The OS expects executable files to have a specific format
  - *Header info*
    - Code locations and size
    - Data locations and size
  - Code & data
  - *Symbol Table*
    - List of names of things defined in your program and where they are defined
    - List of names of things defined elsewhere that are used by your program, and where they are used.

Example of Things

```
#include <stdio.h>
extern int errno;

int main () {

  printf ("hello,
  world\n")

  <check errno for
  errors>
}
```

- Symbol defined in your program and used elsewhere
  - `main`
- Symbol defined elsewhere and used by your program
  - `printf`
  - `errno`

Two Steps Operation: Parts of OS

Linking

- Stitches independently created object files into a single executable file (i.e., a.out)
- Resolves cross-file references to labels
- Listing symbols needing to be resolved by loader

Loading

- copying a program image from hard disk to the main memory in order to put the program in a ready-to-run state
- Maps addresses within file to physical memory addresses
- Resolves names of dynamic library items
- schedule program as a new process

Libraries (I)

- Programmers are expensive.
- Applications are more sophisticated.
  - Pop-down menus, streaming video, etc
- Application programmers rely more on library code to make high quality apps while reducing development time.
  - This means that most of the executable is library code

Libraries (II)

- A collection of subprograms
- Libraries are distinguished from executables in that they are not independent programs
- Libraries are "helper" code that provides services to some other programs
- Main advantages: reusability and modularity

Static Libraries

- These libraries are stored on disk.
- Linker links only the libraries referenced by the program
- Main disadvantage: needs a lot of memory (for example, consider standard functions such as printf and scanf. They are used almost by every application. Now, if a system is running 50-100 processes, each process has its own copy of executable code for printf and scanf. This takes up significant space in the memory.)

Dynamic Link Libraries (Shared Libraries)

- Why not keep those shared library routines in memory and link at object file when needed? (DLLs)
- A shared library is an object module that can be loaded at run time at an arbitrary memory address, and it can be linked to by a program in memory.
- An application can request a dynamic library during execution
- Main advantage: saving memory
- Main disadvantage: ~10% performance hit

A Bit About Relocation

- modifies the object program so that it can be loaded at an address different from the location originally specified
- The compiler and assembler (mistakenly) treat each module as if it will be loaded at location zero

(e.g. ***jump 120***
is used to indicate a jump to location 120 of the current module)

A Bit About Relocation

- To convert this relative address to an absolute address, the linker adds the base address of the module to the relative address.
- The base address is the address at which this module will be loaded.

Example: Module A is to be loaded starting at location 2300 and contains the instruction

jump 120

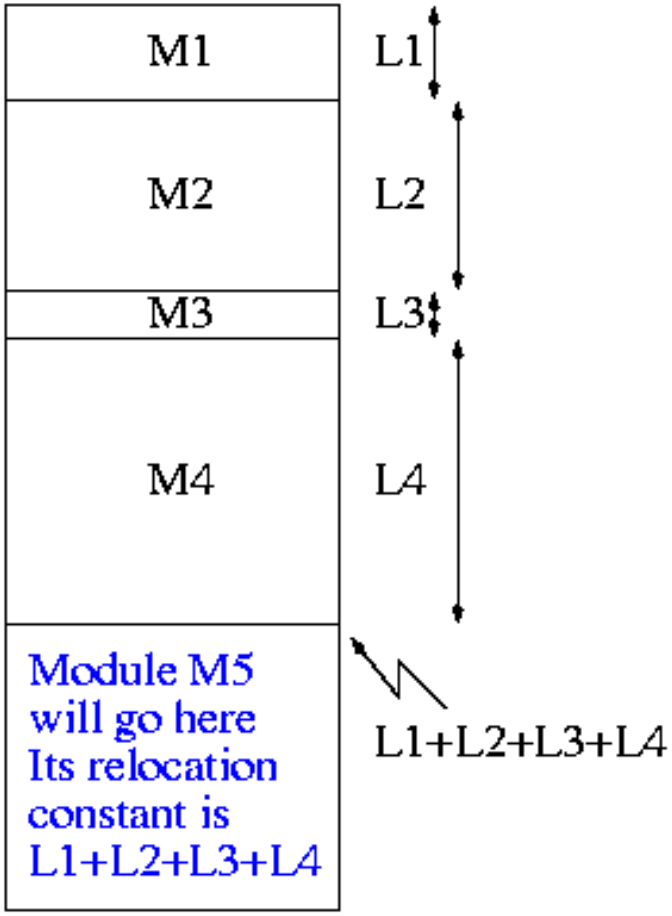
The linker changes this instruction to

jump 2420

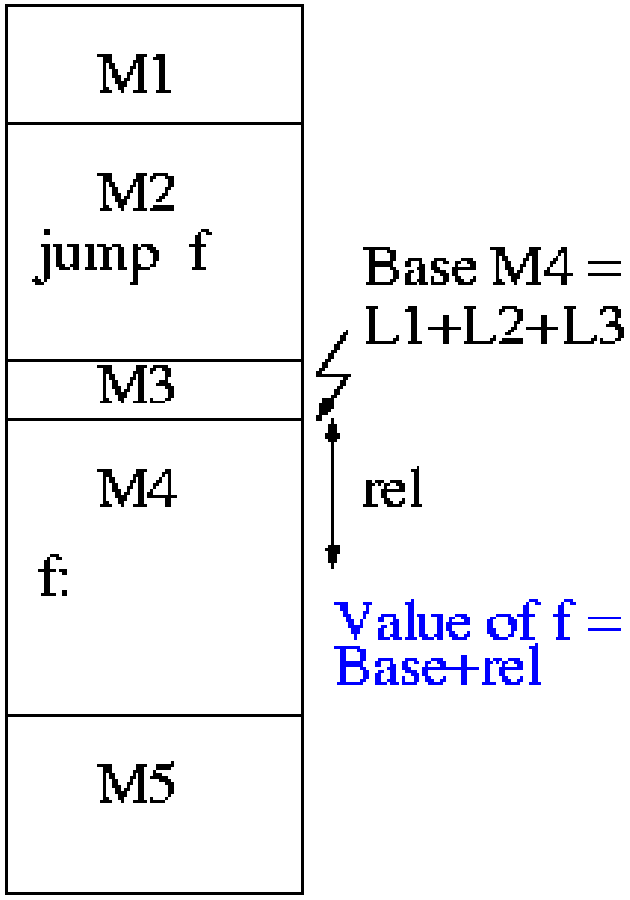
A Bit About Relocation

- How does the linker know that Module A is to be loaded starting at location 2300?
  - It processes the modules one at a time. The first module is to be loaded at location zero. So relocating the first module is trivial (adding zero). We say that the relocation constant is zero.
  - After processing the first module, the linker knows its length (say that length is L1).
  - Hence the next module is to be loaded starting at L1, i.e., the relocation constant is L1.
  - In general the linker keeps the sum of the lengths of all the modules it has already processed; this sum is the relocation constant for the next module.

A Bit About Relocation



A Bit About Relocation



Enough for Today

- OS is really a manager:
  - programs, applications, and processes are the customers
  - The hardware provide the resources
- OS works in different environments and under different restrictions (supercomputers, workstations, notebooks, tablets, smartphones, real-time, …)