NYU
New York University

Operating Systems

Introduction

Mohamed Zahran (aka Z)
mzahran@cs.nyu.edu
http://www.mzahran.com

Who Am I?

- Mohamed Zahran (aka Z)
- Computer architecture/OS/Compilers Interaction
- http://www.mzahran.com
- Office hours [ONLINE]
  - Tue 2-3pm
  - or by appointment if you cannot make the above time slot.
  - Zoom link posted on course website as well as on Brightspace .

Formal Goals of This Course

- What exactly is an operating systems?
- Why do we need one?
- How does the OS interact with the hardware and the other software applications?
- Main concepts of an OS:
  - Processes
  - Threads
  - Memory Management
  - Filesystems
  - I/O

Informal Goals of This Course

- To get you interested in OS inner working
- To use what you have learned in *MANY* different contexts
- To be able to develop your own OS, or some parts of it, if you want
- To start your research project in OS if you want
- To get more than an *A*

Web Presence

Brightspace

- Announcements
- Forums
- Submissions (of assignments, labs, etc)
- Getting solutions of homework assignments
- Getting your grades

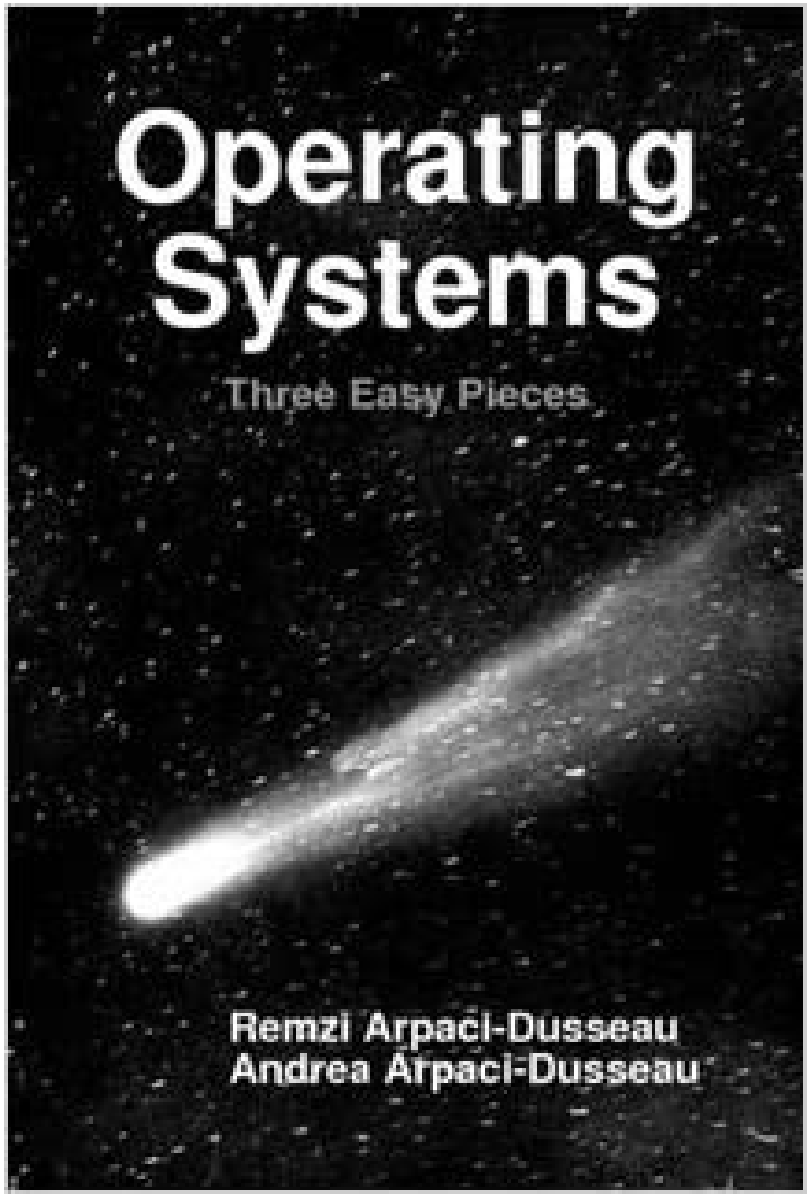
Course Website

- Lecture slides
- Reading material
- The assignments
- Useful links

Zoom: Lecture meetings and office hours

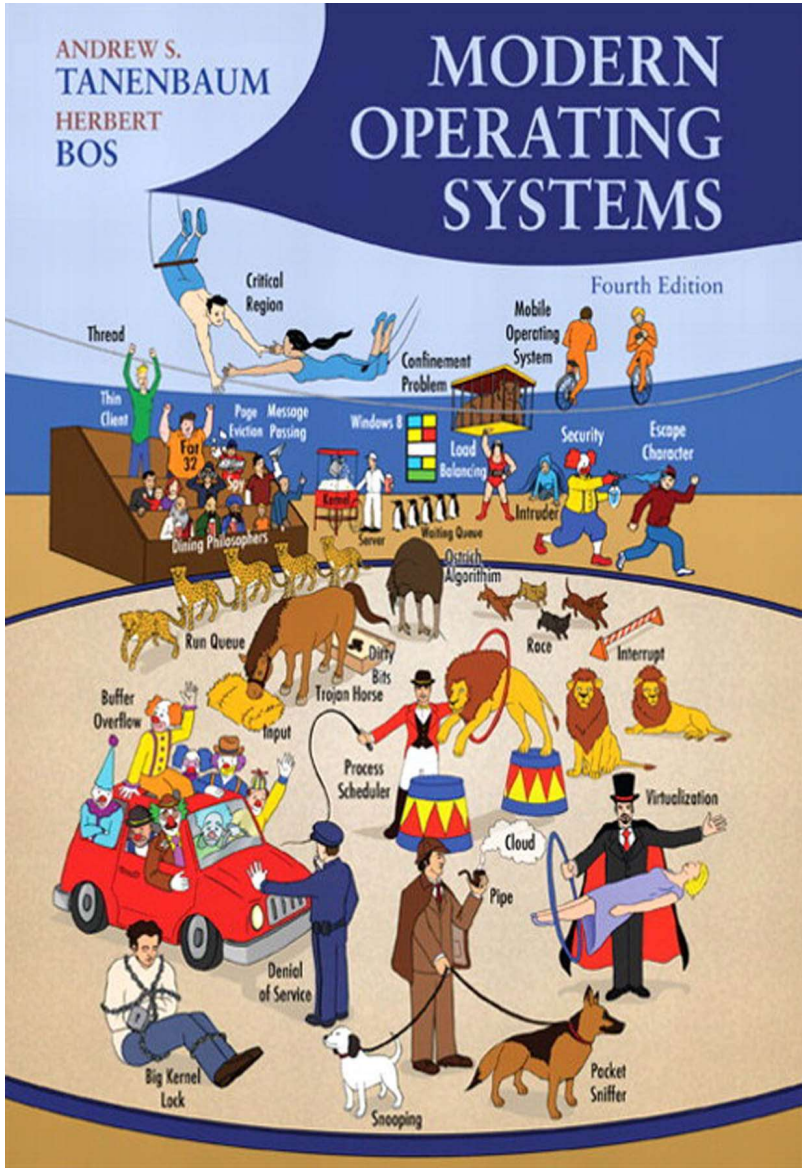
The Textbook

- http://www.ostep.org
- Available for free online
- Required



The Textbook

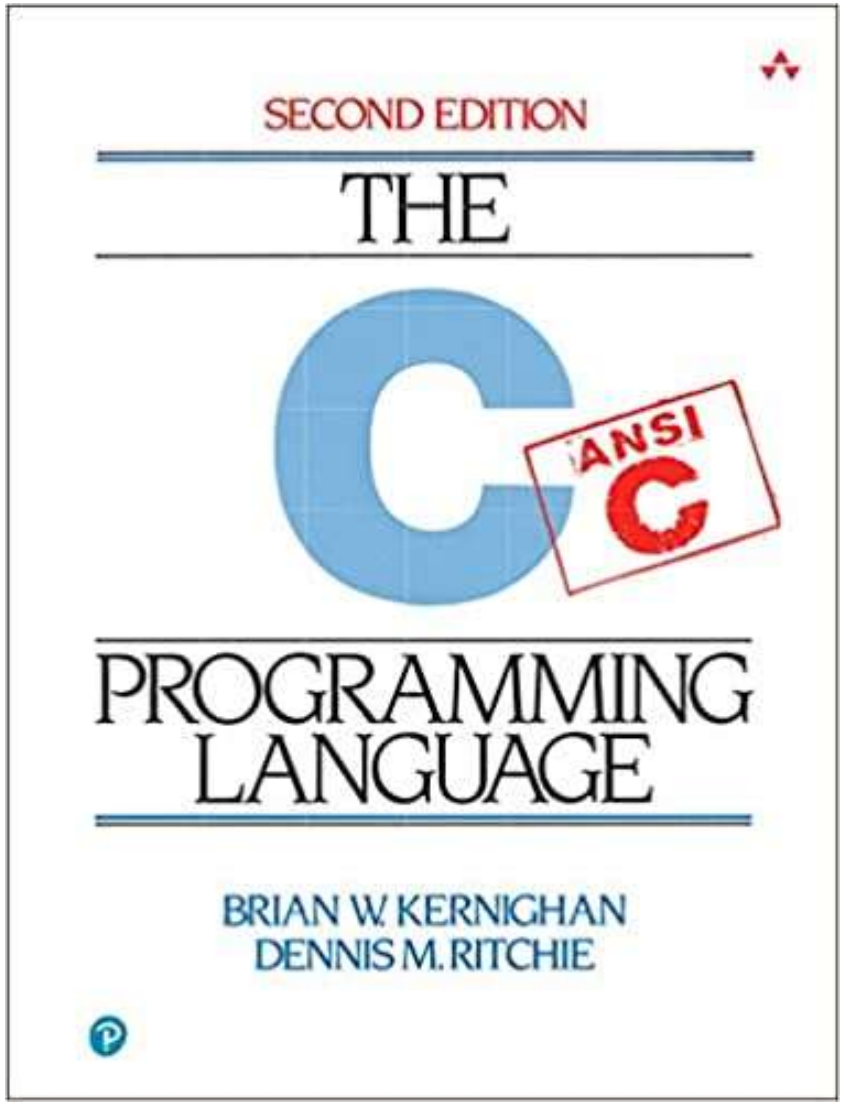
- Recommended but not required



You may need this:

- Good source to refresh your memory about C

Any other C textbook or online tutorial will do.



Course Components

- **Lectures**
  - Higher level concepts
  - slides + reading material from the textbook
- **Programming Labs** (~3 of them → 30%)
  - 1-2 weeks each
  - Provide in-depth understanding of some aspect of systems
- **Homework Assignments** (~3 of them →10%)
  - Labs do not cover all the material we will study!
  - For theoretical knowledge
- **Midterm Exam** (25%)
- **Final Exam** (35%)

Policies: Assignments

- You must work alone on all assignments
  - Post all questions on the forums on Brightspace
  - You are encouraged to answer others' questions but refrain from explicitly giving away solutions.
- Hand-ins
  - Labs/homework assignments due at 11:59pm on the due date
  - Submitted through Brightspace

Integrity

- Academic integrity
- Your homework, labs, and exams must be your own.
- Both the cheater and the student who aided the cheater will be held responsible for the cheating

Integrity and Collaboration

- What is **cheating**?
  - **Sharing code**: by copying, retyping, **looking at**, or supplying a file
  - **Describing code**: verbal description of code from one person to another.
  - **Coaching**: helping your friend to write a lab, line by line
  - **Searching the Web** for solutions
  - **Copying code from a previous course or online solution**
    - You are only allowed to use code we supply

- What is NOT cheating?
  - Explaining how to use systems or tools
  - Helping others with high-level design issues

- Ignorance is not an excuse

We have sophisticated tools for detecting code plagiarism

What can positively affect your grade (i.e. help me boost your final grade)?

- Participate in the forums on Brightspace, by asking questions or answering questions of other.
- Submit your assignments on time and in the correct format.

What can negatively affect your grade ?

- Coming up with a lot of excuses to get extensions (except documented health problems) or higher grades, examples:
  - My machine crashed just before the deadline. You better submit a version each time you complete part of the lab. You are allowed to submit several times. We will grade the last submission.
  - I have many assignments on other courses so please give me extension.
  - I submitted one minute after the deadline but the server did not accept it.
  - I submitted an older version of the lab or a wrong file.
- Asking questions on the forums that have been asked before.
  - Yes, you better read the previous questions and answers on the forums. It is a good way of studying because people may ask good questions that did not come to your mind.

Some Unacceptable Questions

- I spent 100 hrs/week studying for this course, why didn't I get a high grade?
  - Do you really think that your grade is just a function of how much you study?
- What do I concentrate on when studying for the exam?
  - Do you really mean that some parts of the material are not important?

Arguing a grade of an assignment, lab, or exam.

You have one week from the time you receive your assignment/exam grade to argue about it if you want.

- If lab/homework, first discuss the issue with the grader.
- If issue is not resolved, then come to me.
- For exams, come to me directly.

After that, no arguments are allowed.

What to study to get good grade?

- The slides of each lecture (You will find them on the course website)
- The reading material of each lecture, if any (You will find them on the course website)
- The questions and answers in the forums (You will find them on the Brightspace)

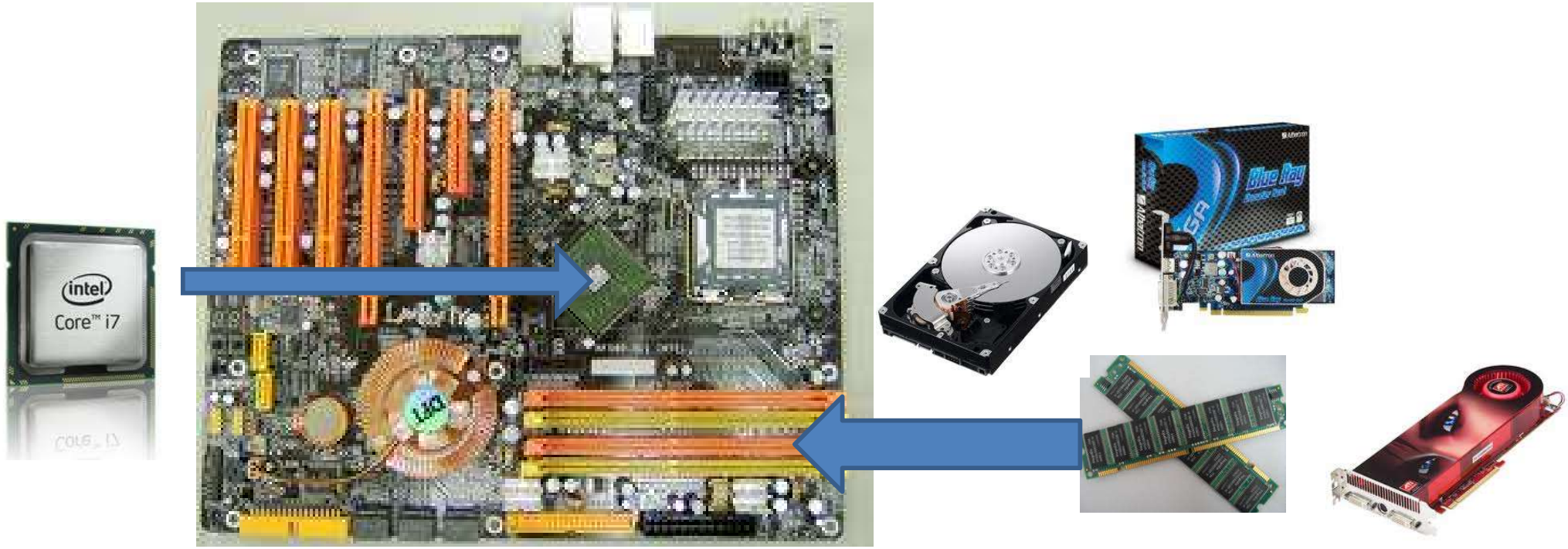
Important!!

Attending the lectures helps you a lot understanding the material of this course.

Do not rely on just reading the slides, the reading material, and web search.

Question: What is an OS?

Question: Why do we need an OS?

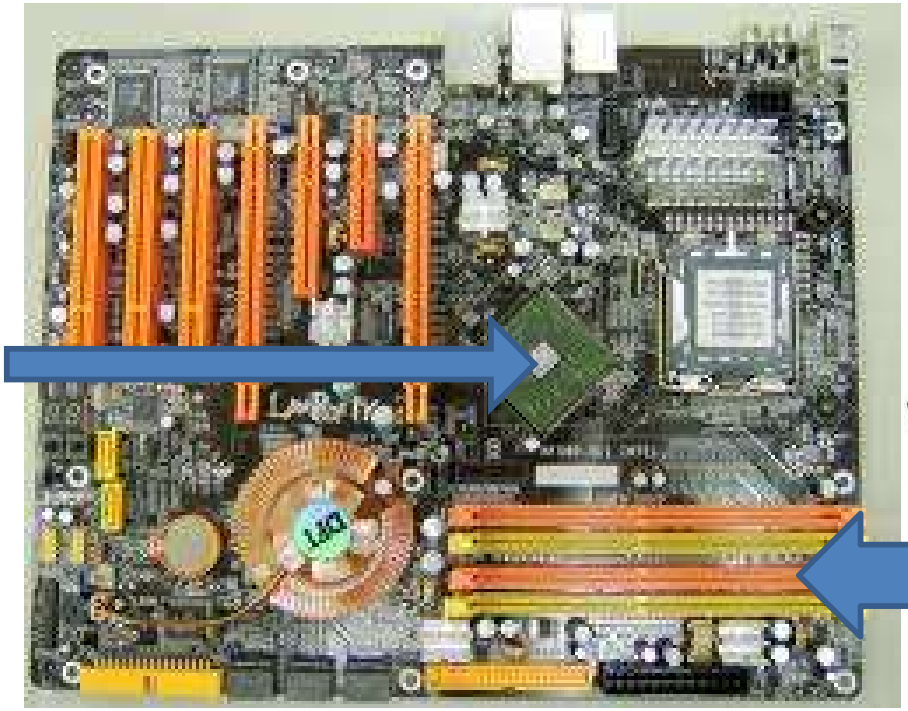

intel
Core™ i7
Blue Ray

Media Player

emails

Games

Word Processing



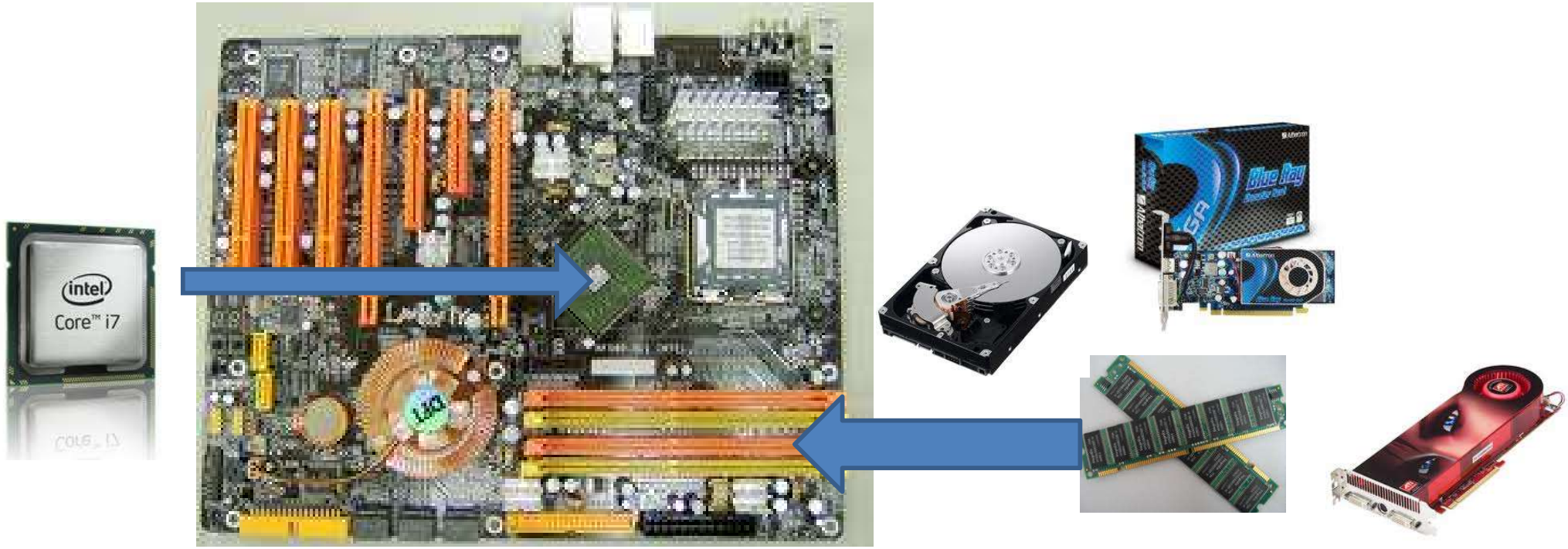
Media Player

emails

Games

Word Processing

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



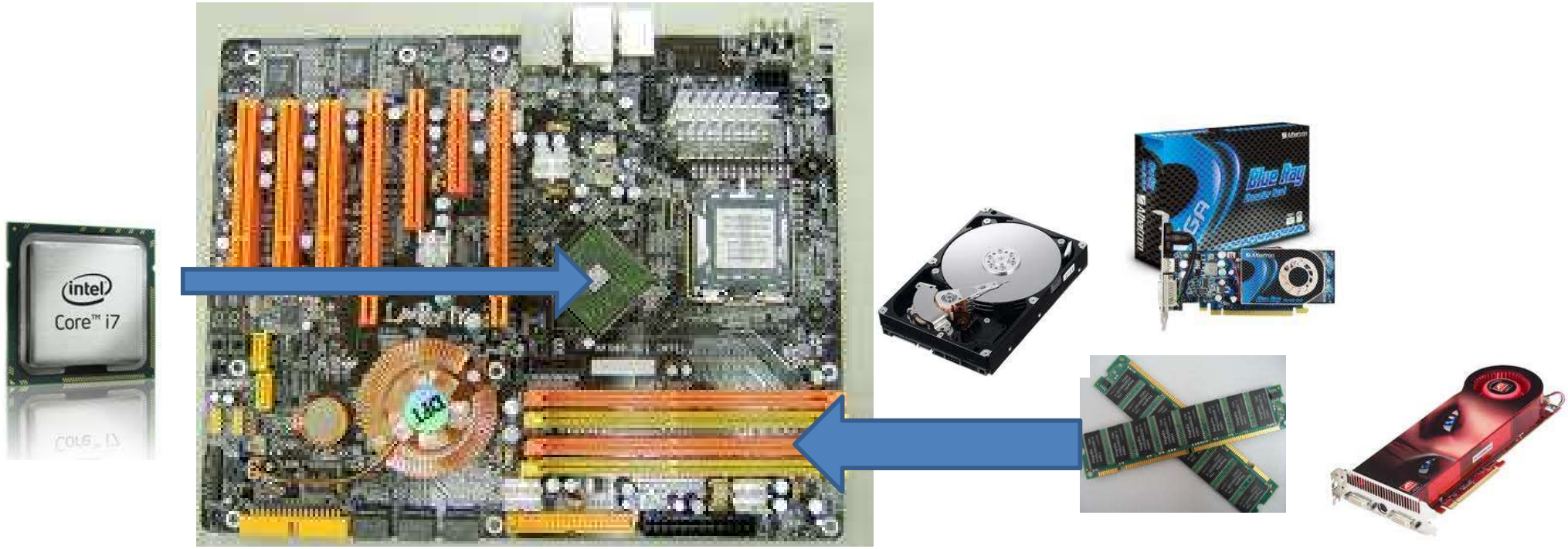
Media Player

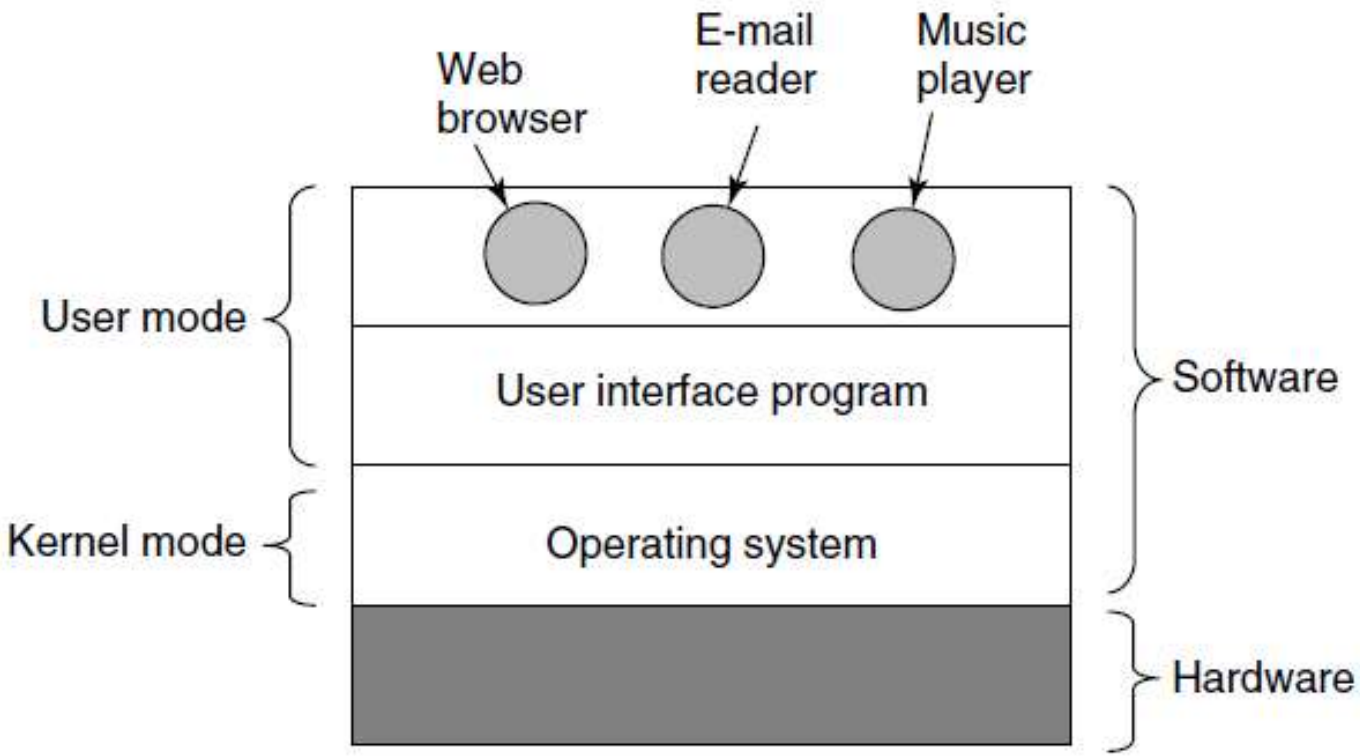
emails

Games

Word Processing

Operating System

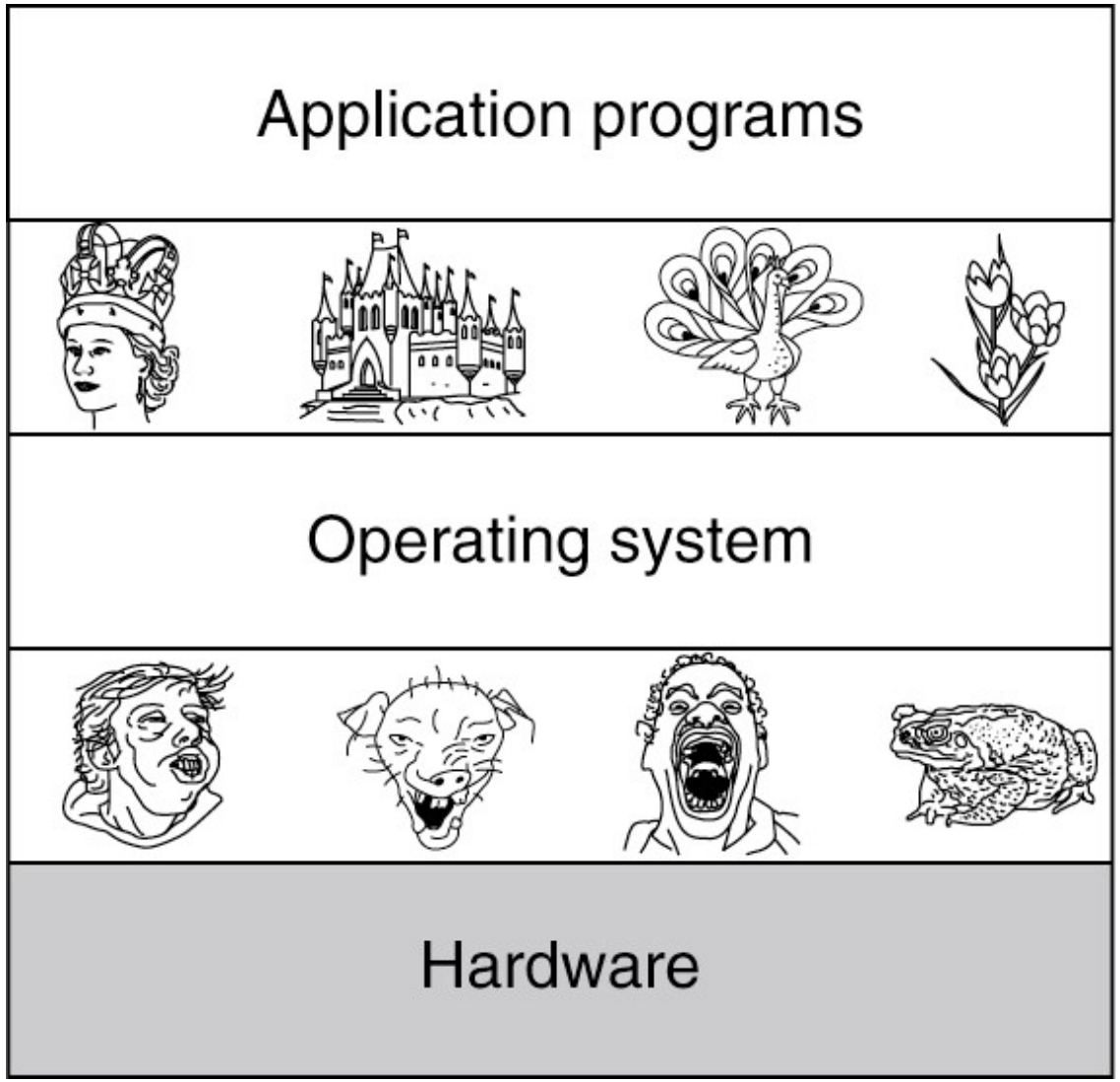



Web browser
E-mail reader
Music player
User mode
User interface program
Software
Kernel mode
Operating system
Hardware

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

How did the OS evolve? A bit of history …

- The first generation (1945-55) vacuum tubes
- The second generation (1955-65) transistors and batch systems
- The third generation (1965-1980) ICs and multiprogramming
- The fourth generation (1980-present) personal computers
- The fifth generation (1990-present) mobile computers

How does the OS perform its two main tasks (providing abstract and managing resources)?

Answer: Through three easy pieces

The Three Easy Pieces of the OS

Virtualization

Concurrency

Persistence

The Three Easy Pieces of the OS

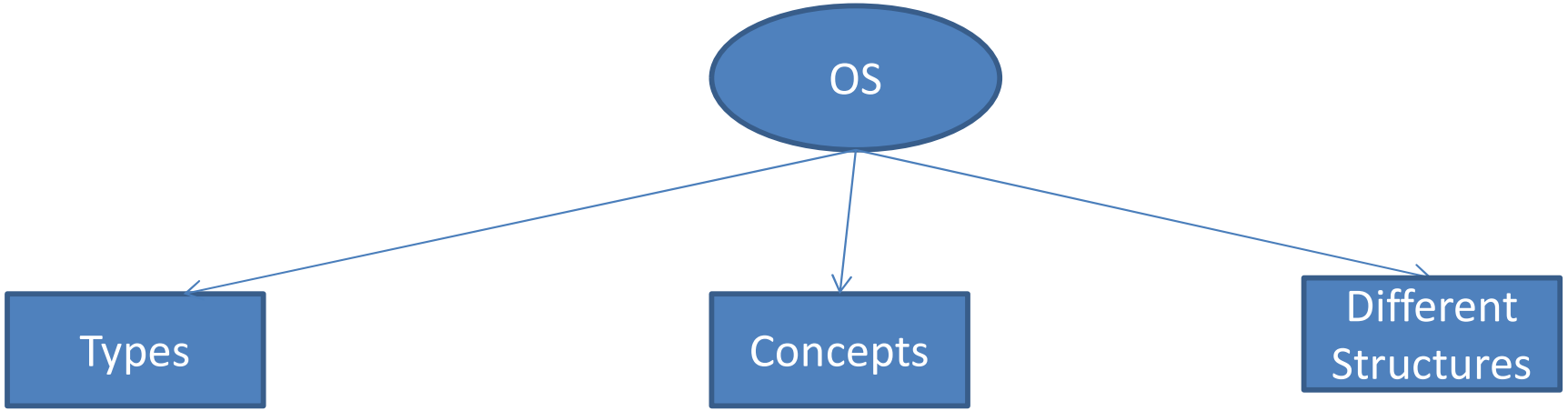
Virtualization → of the CPU and Memory

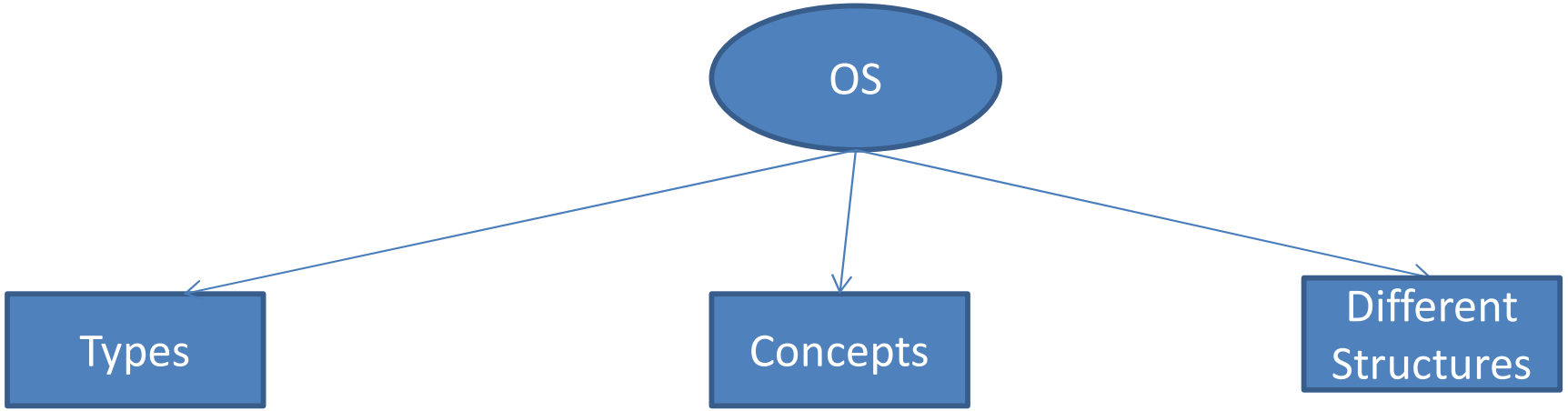
Concurrency → parallel programs

Persistence → the filesystem on the disk

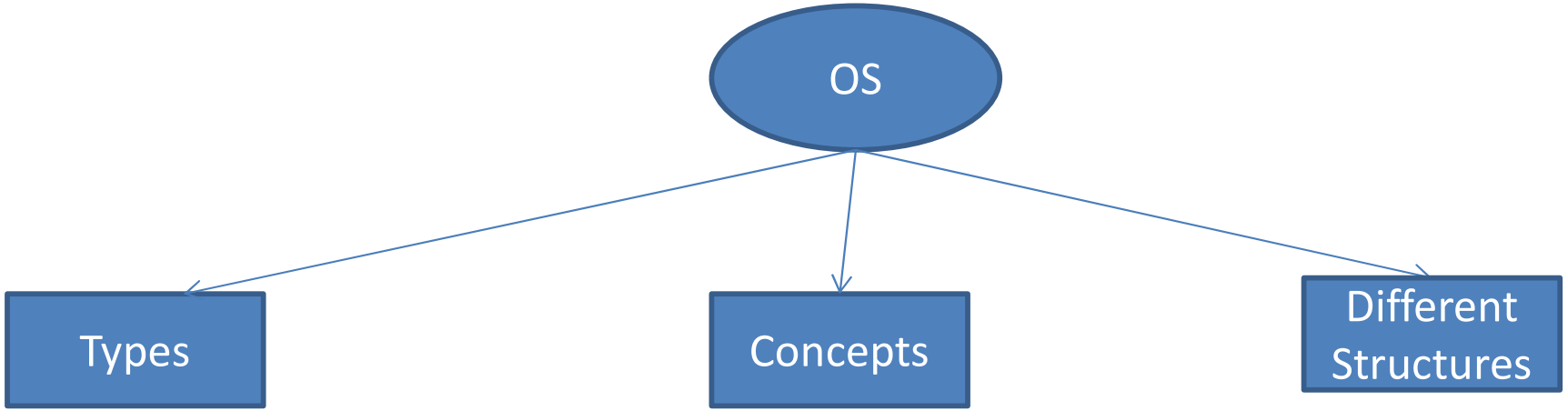
Main Goals of an OS

- Convenience: set of standard libraries (APIs or Application Programs Interface)
- Abstraction
- Performance
- Energy-efficiency
- Isolation and Protection
- Reliability
- Ability to evolve


OS
Types
Concepts
Different Structures

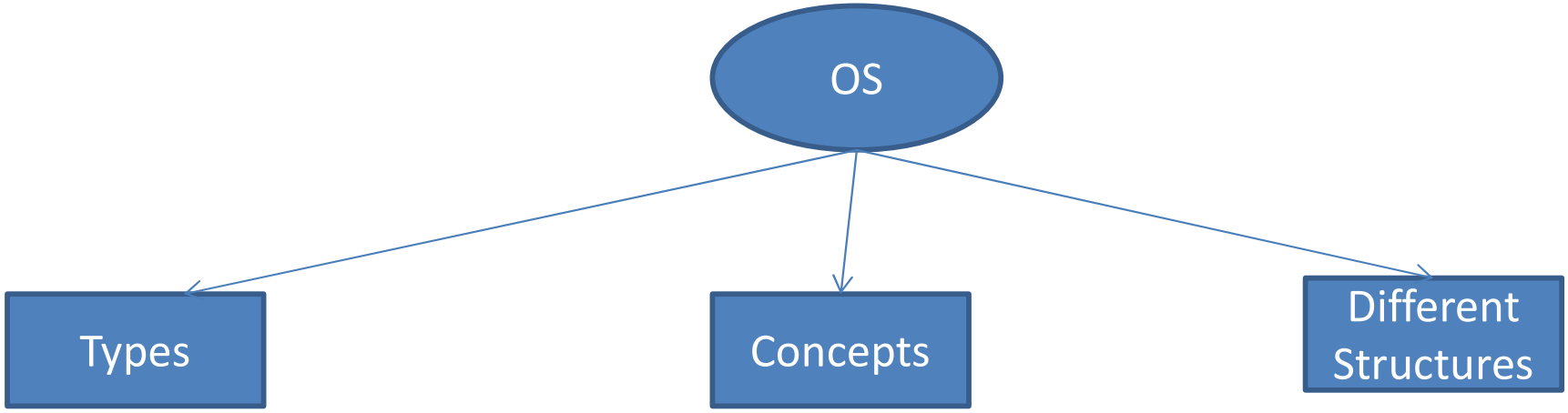


- **Supercomputer OS**
- **Server OS**
- **Multiprocessor OS**
- **PC OS**
- **Embedded OS**
- **Sensor node OS**
- **RTOS**
- **Smart card OS**
- **... etc**



- Supercomputer OS
- Server OS
- Multiprocessor OS
- PC OS
- Embedded OS
- Sensor node OS
- RTOS
- Smart card OS
- ... etc

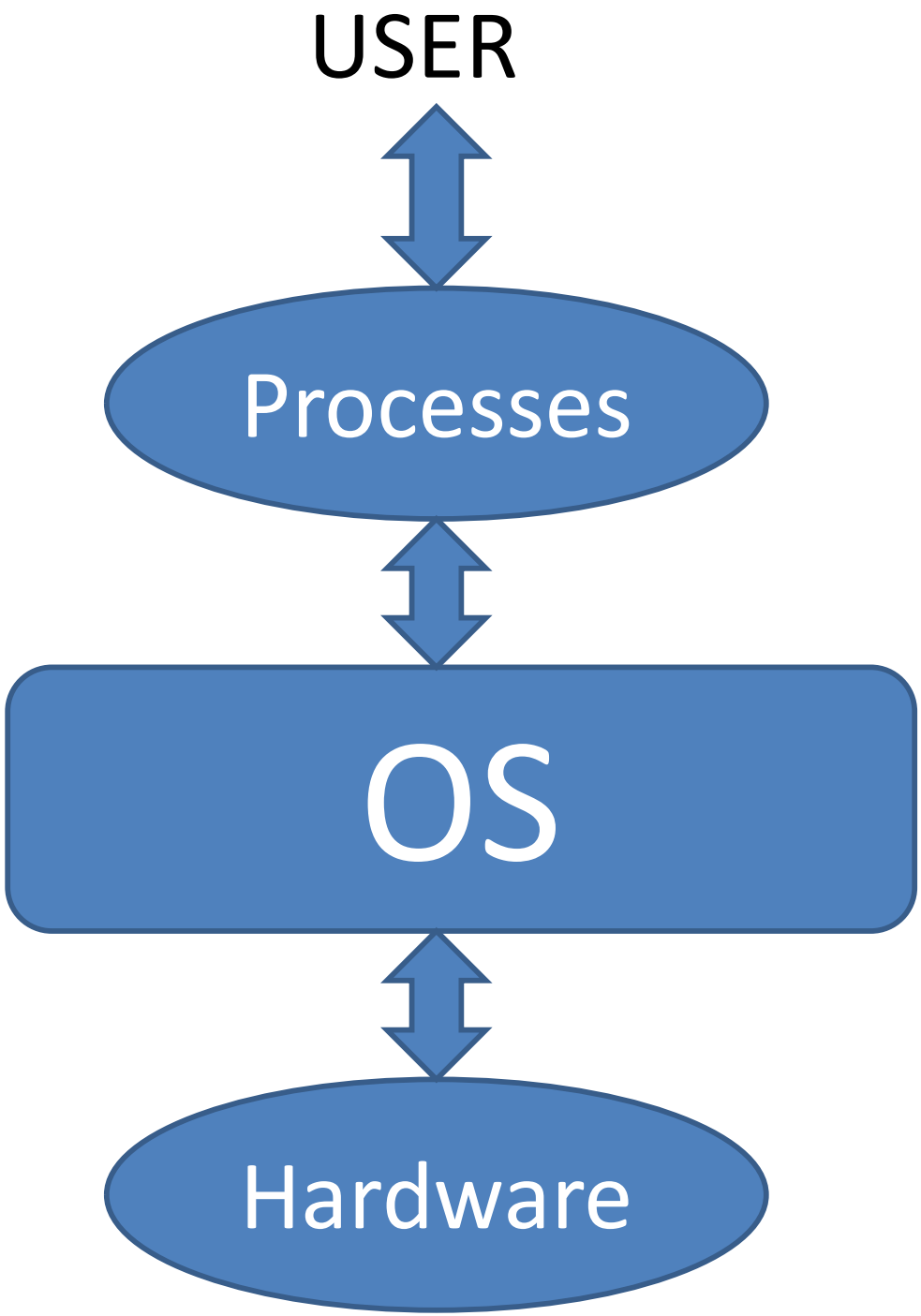
- **Processes**
- **Threads**
- **Memory Management**
- **File system**
- **I/O**

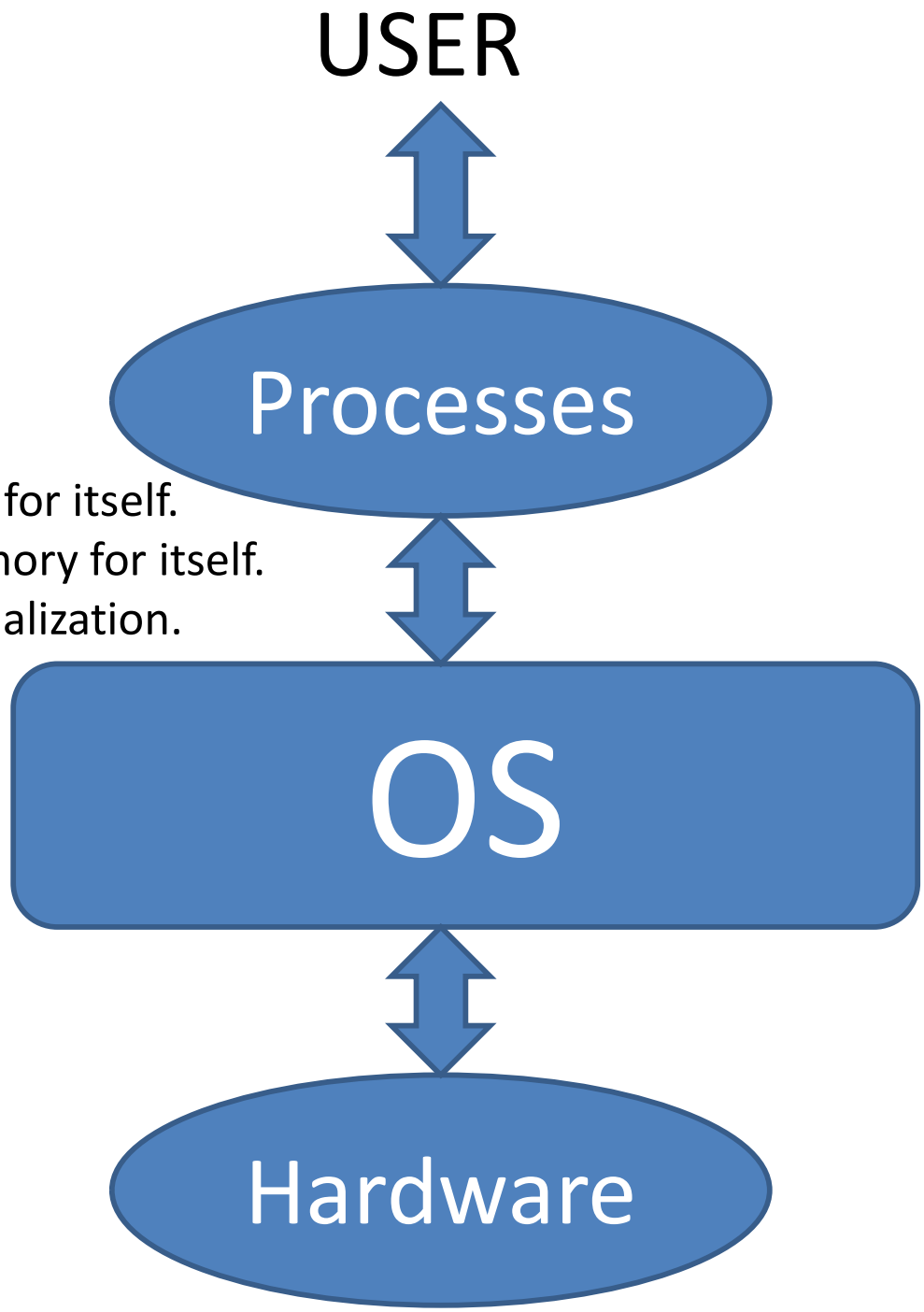


- Supercomputer OS
- Server OS
- Multiprocessor OS
- PC OS
- Embedded OS
- Sensor node OS
- RTOS
- Smart card OS
- ... etc

- Processes
- Threads
- Memory Management
- File system
- I/O

- **Monolithic**
- **Layered systems**
- **Microkernels**
- **Virtual machines**
- **... others**


USER
Processes
OS
Hardware



Each process thinks:

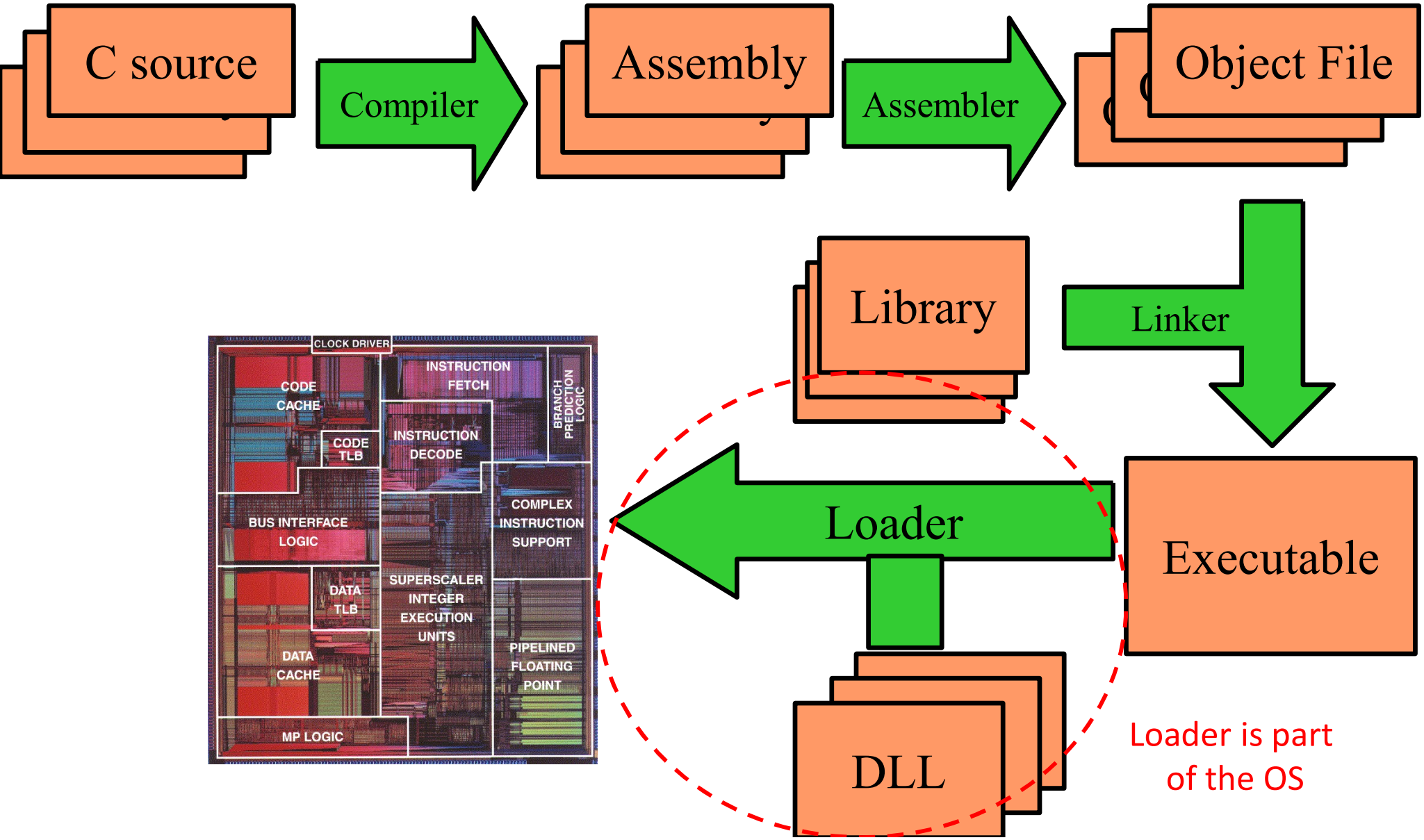
- It has the whole CPU for itself.
- It has the whole memory for itself.

This is what we call virtualization.

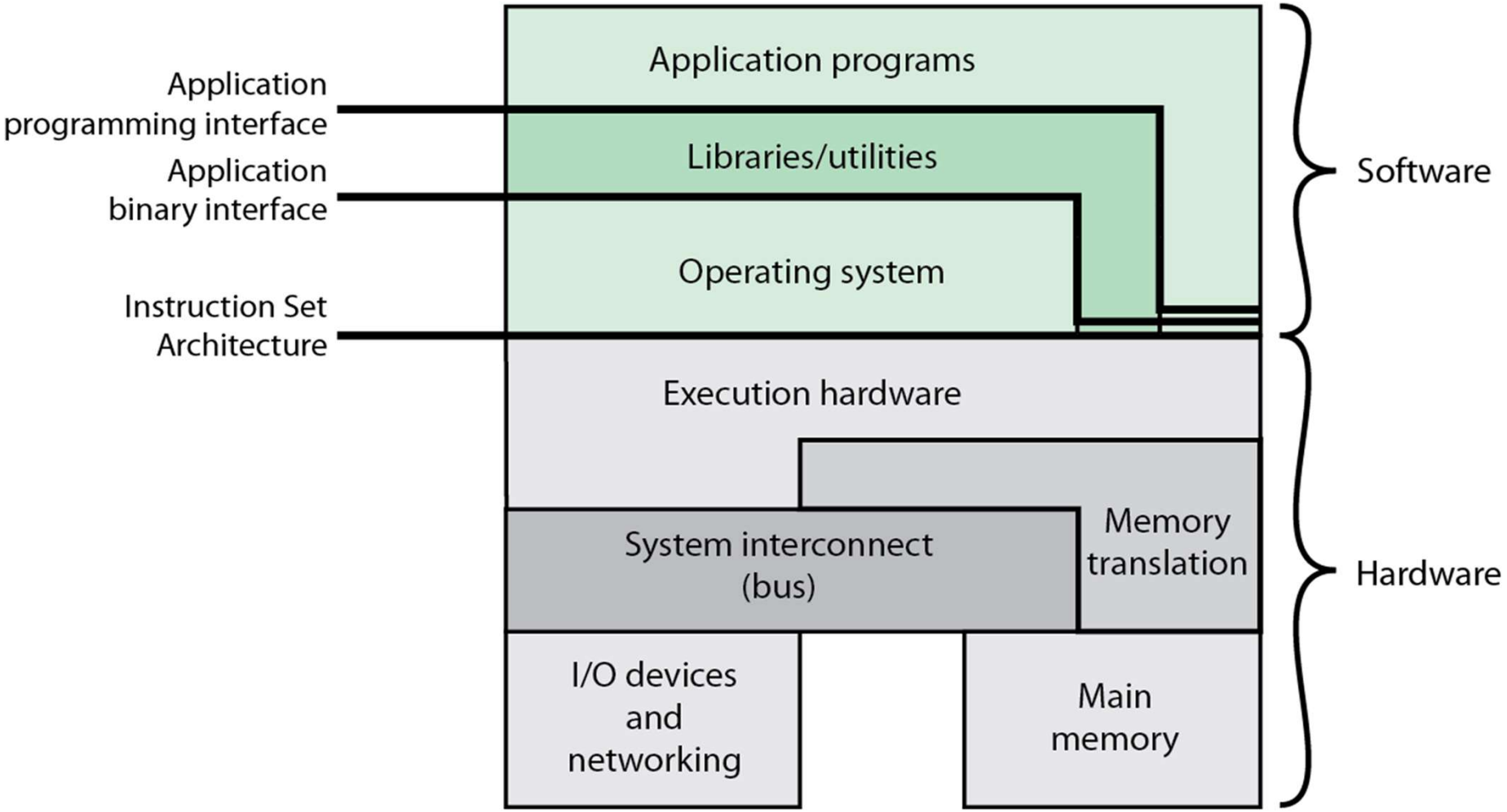
A Process

- Key concept in all operating systems
- Definition: a program in execution
- Process is associated with an address space
- Also associated with set of resources
- Process can be thought of as a container
  - Holds all information needed to run program

Source Code to Execution



Hardware and Software Infrastructure



Computer Hardware and Software Infrastructure

Hardware and Software Infrastructure

Enough for Today

- OS is, at its core, a manager:
  - Processes are the customers
  - The hardware provides the resources

- Now is the best time to start reviewing C