

COMPUTER SYSTEMS ORGANIZATION

Introduction -- Spring 2010 -- IIIT-H -- Suresh Purini

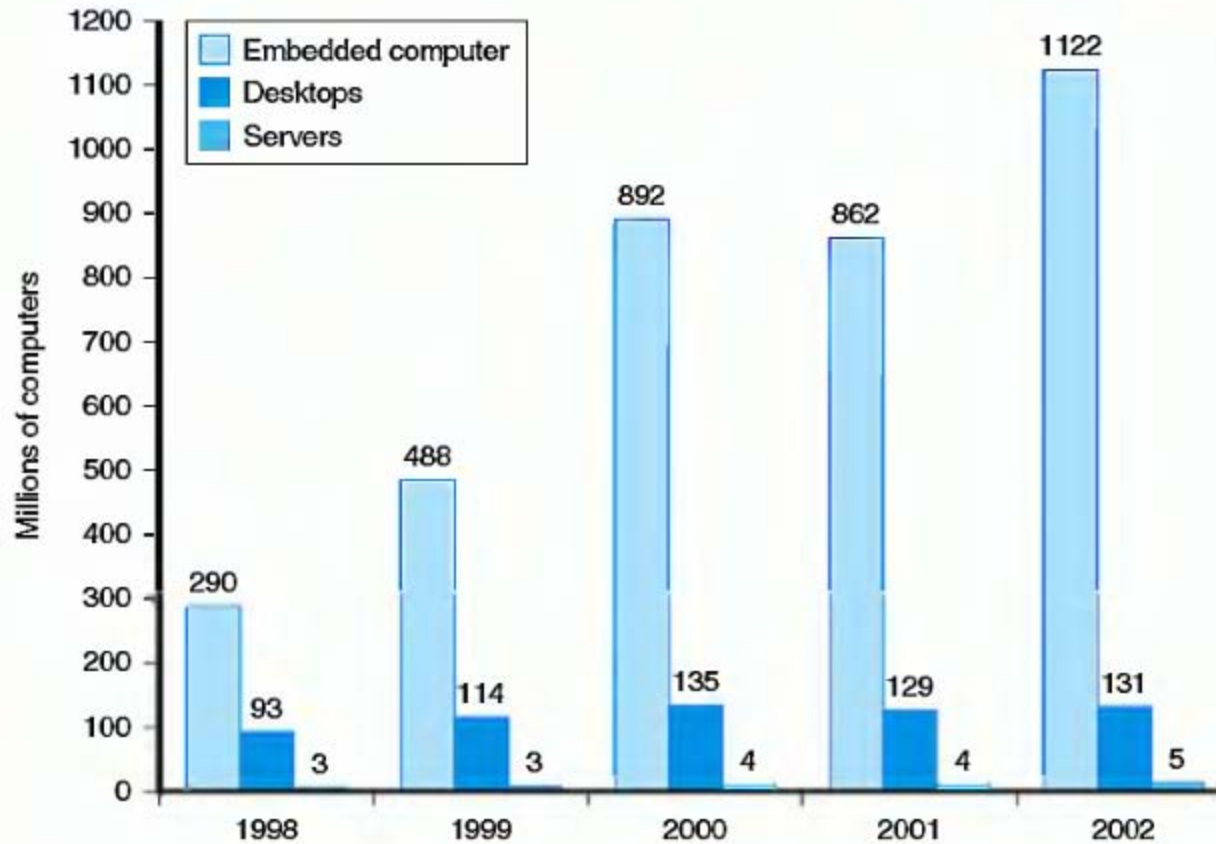
Basic Course Goal

- ❑ **Course Goal:** To study the anatomy of a typical Computer System.
- ❑ Well, what is a typical computer system?
 - ❑ Desktops, Laptops, Netbooks (really?)
- ❑ How about Server Machines?
 - ❑ In what way they are different from Desktops/Laptops?
- ❑ How about Embedded Computers lying inside Cell Phones, Automobiles, Airplanes, Set Top Boxes, Televisions etc.



Sales Distribution

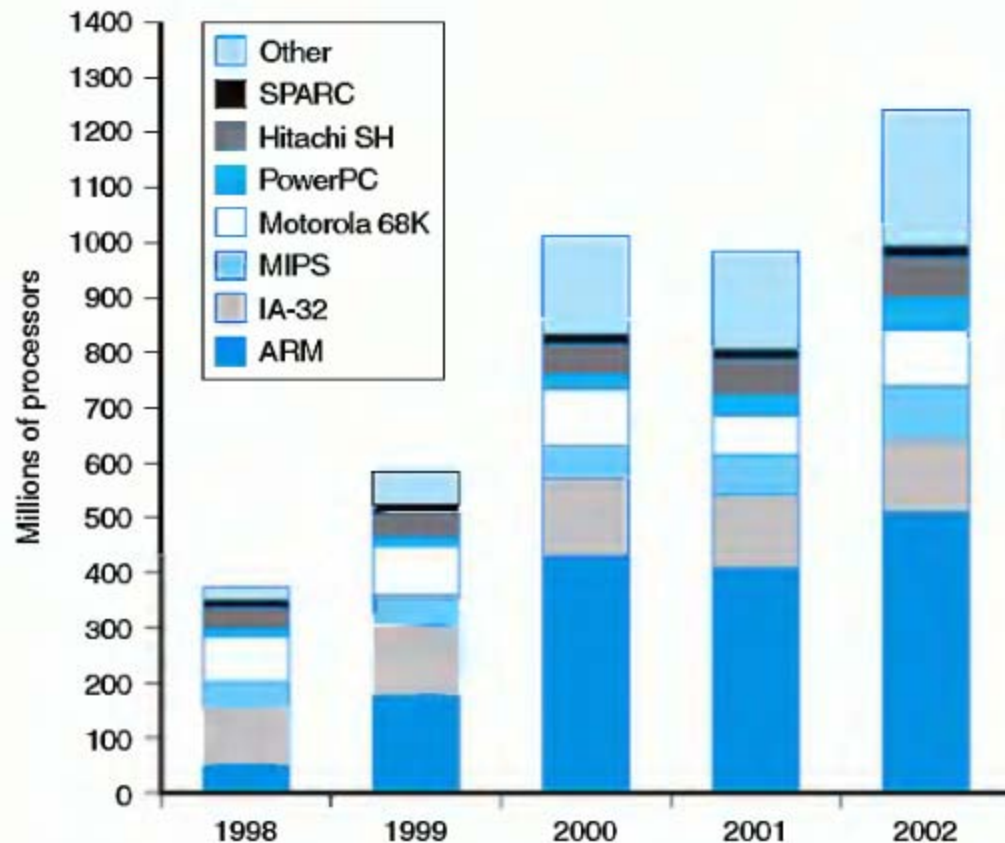
Source: H&P-3 (Hennesy & Patterson, 3rd Edition)



Number of distinct processors sold between 1998 and 2002.

Sales Distribution

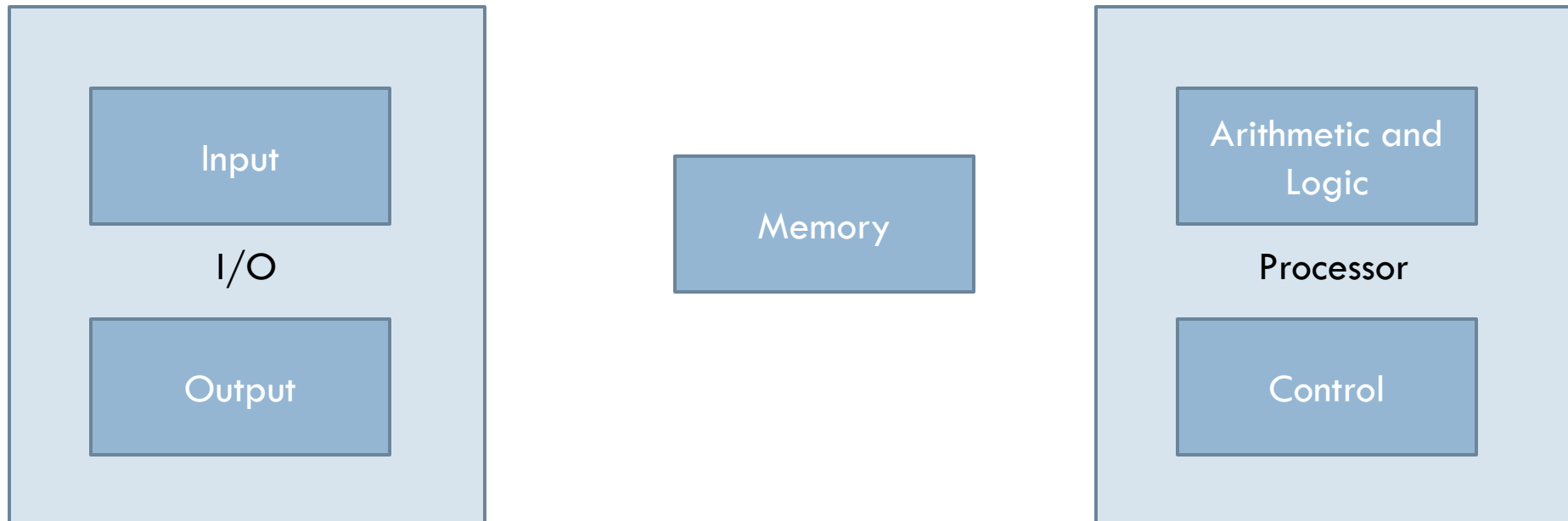
Source: H&P-3



Sales of microprocessors between 1998 and 2002 by instruction set architecture

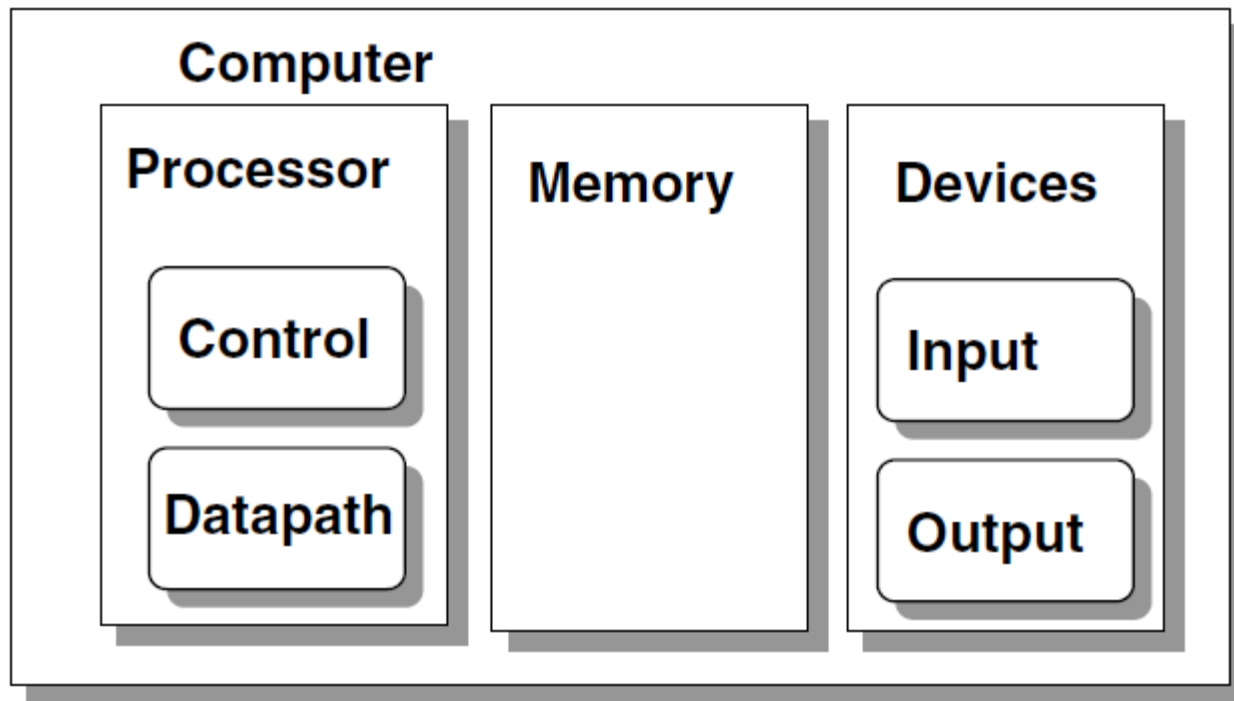
Major Functional Units of a Computer

Embedded Computers, Desktops and Servers are composed of three main parts functionally.



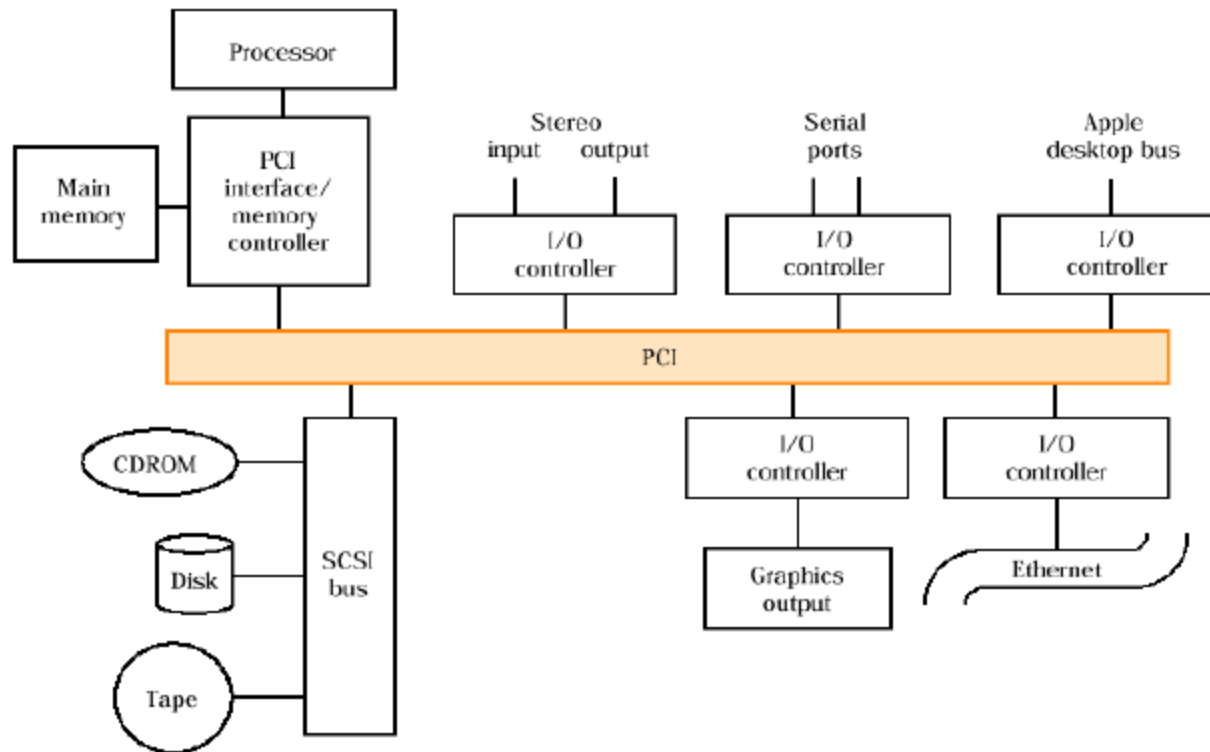
These Three Components can be interconnected in many ways.

Major Function Units



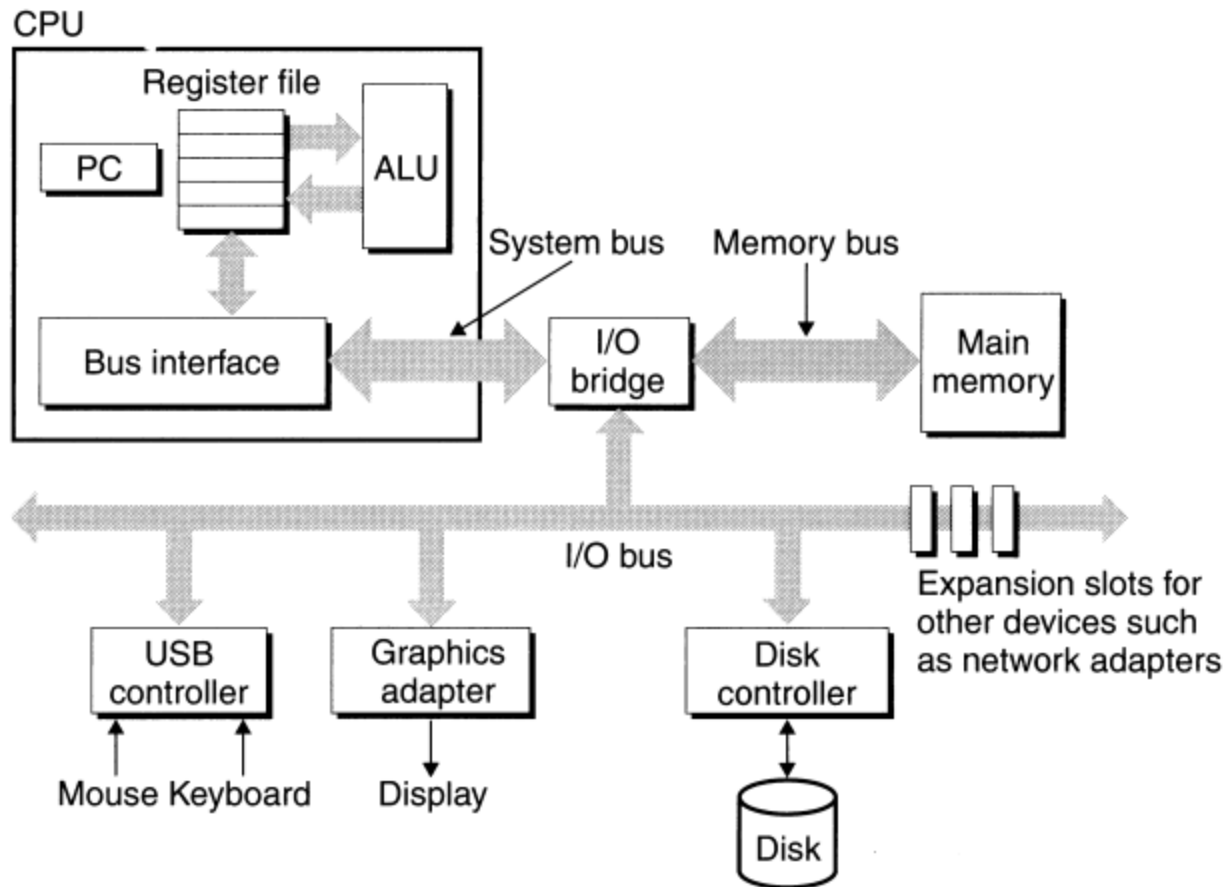
Source: Prof. Cheung's Course Notes (Imperial College, London)

Typical Hardware Organization of a System



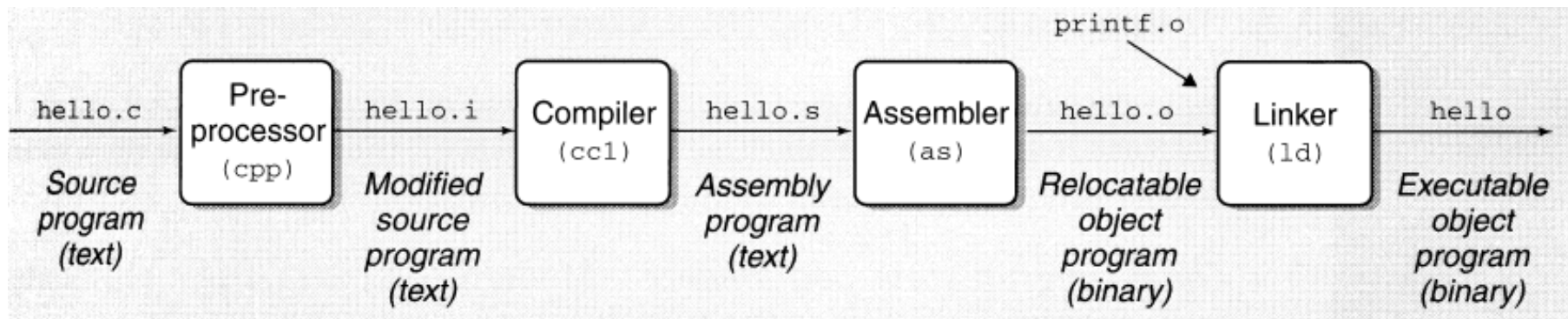
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Typical Hardware Organization of a System

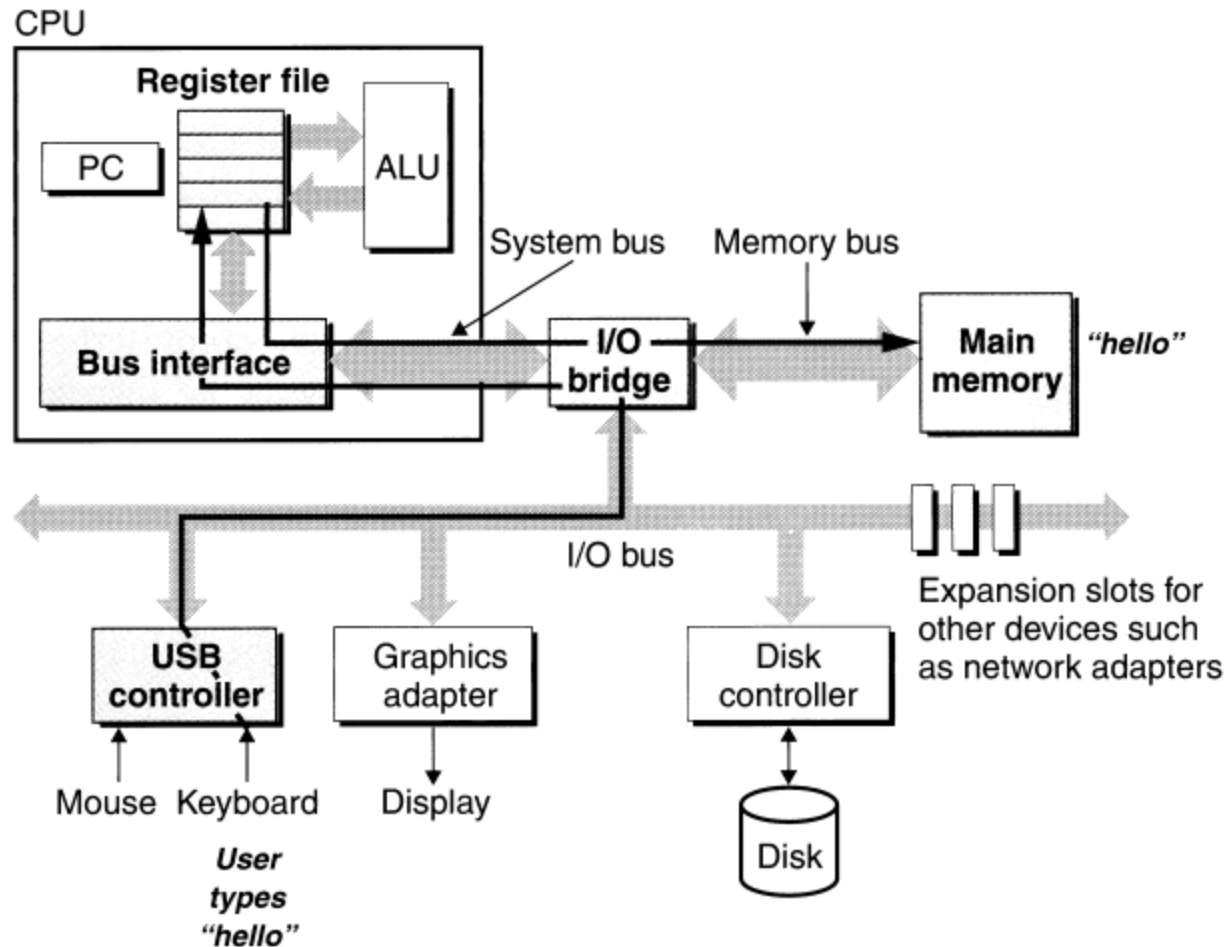


Source: RB&DO -1 (Randal E. Bryant & David O'Hallaron, 1st Ed)

Typical Compilation Sequence

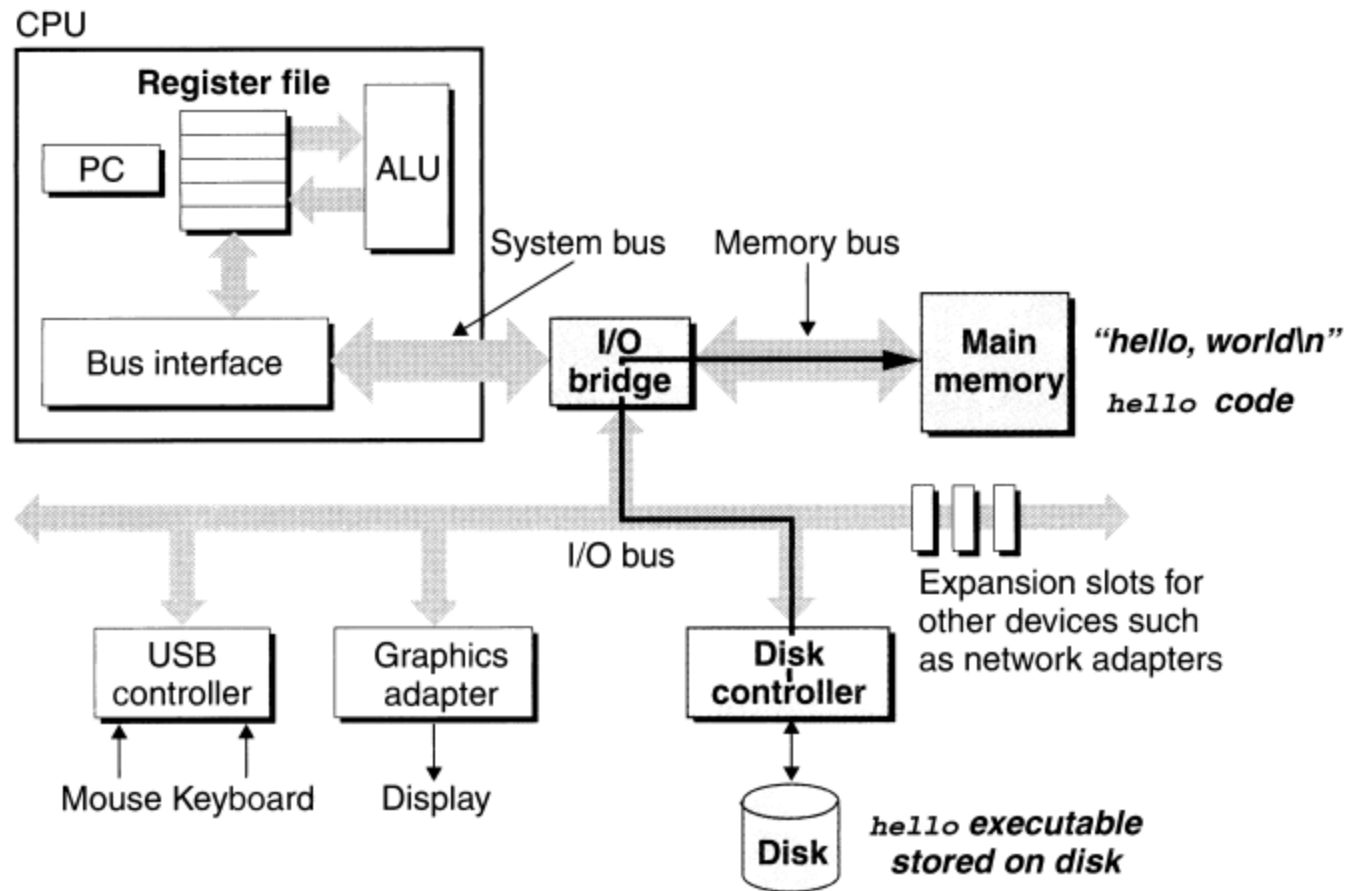


Running the “Hello World” Program

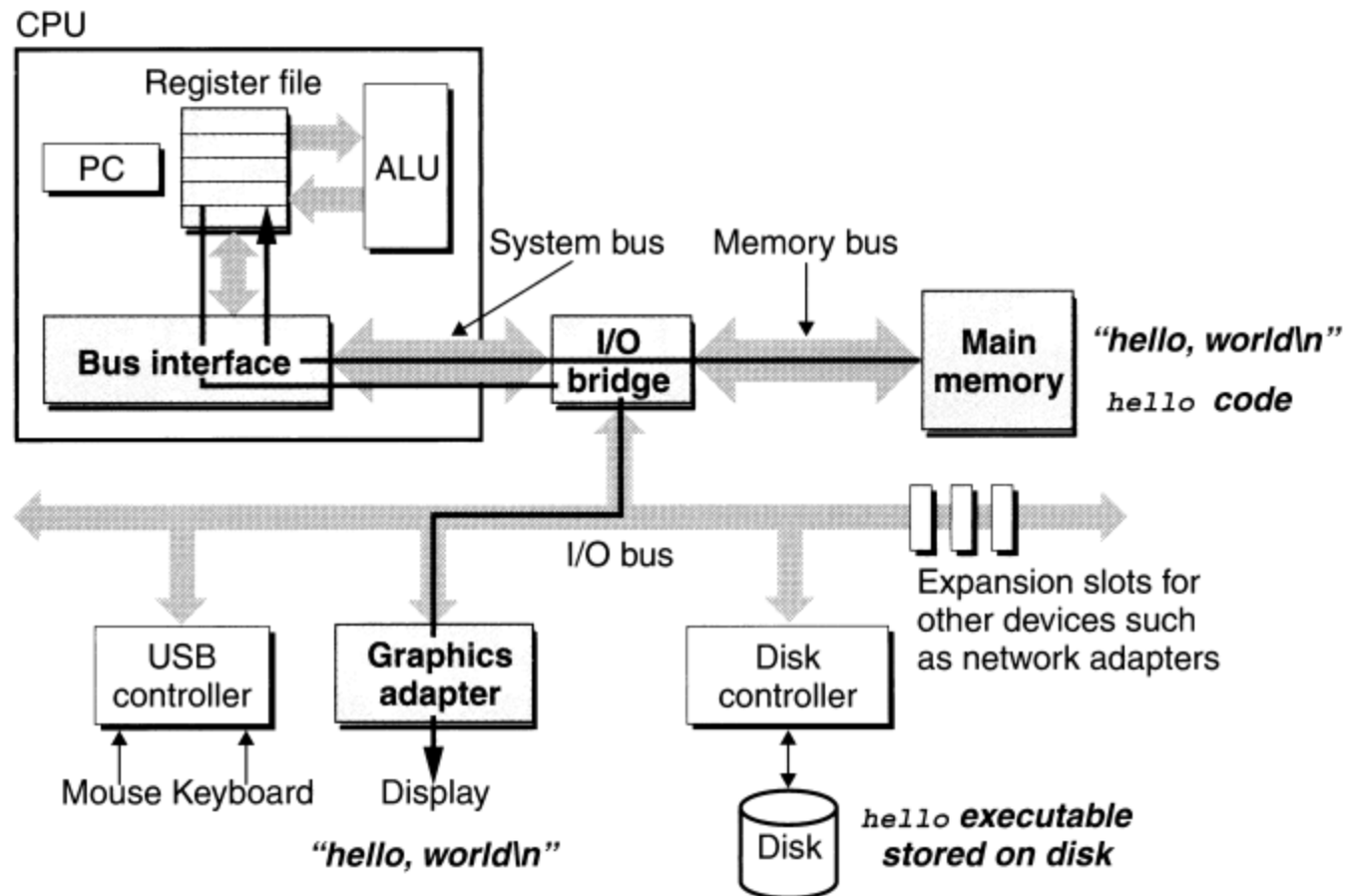


Source: RB&DO-1

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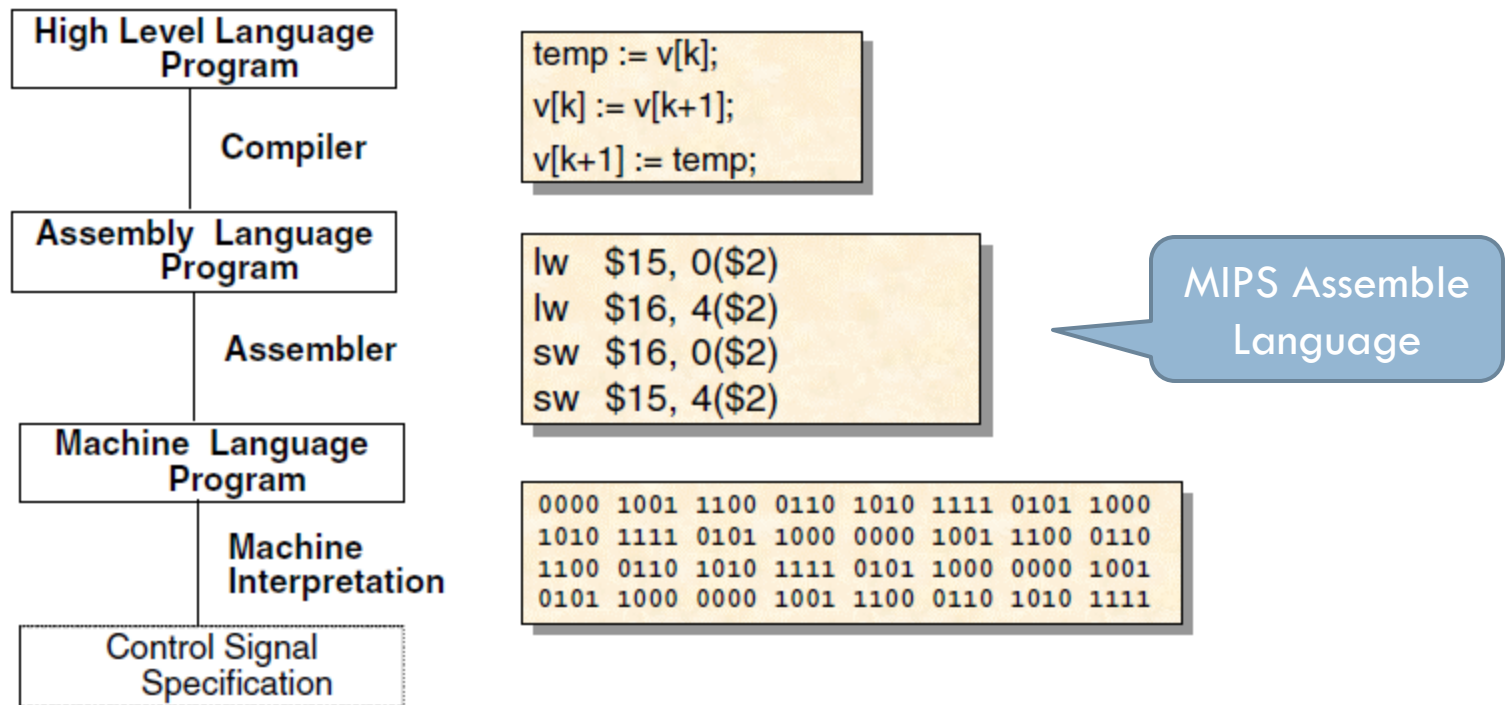


Programming Abstractions

We can program a microprocessor using

- a) Instruction opcodes (also called Machine Code)
 - b) Assembly language
 - c) High level programming languages
-
- ❑ The level of **abstraction** increases from Top to Bottom.
 - ❑ As the level of abstraction increases, ease of programmability also increases!
 - ❑ Hmm, but we may lose the fine-grained control over the underlying hardware?

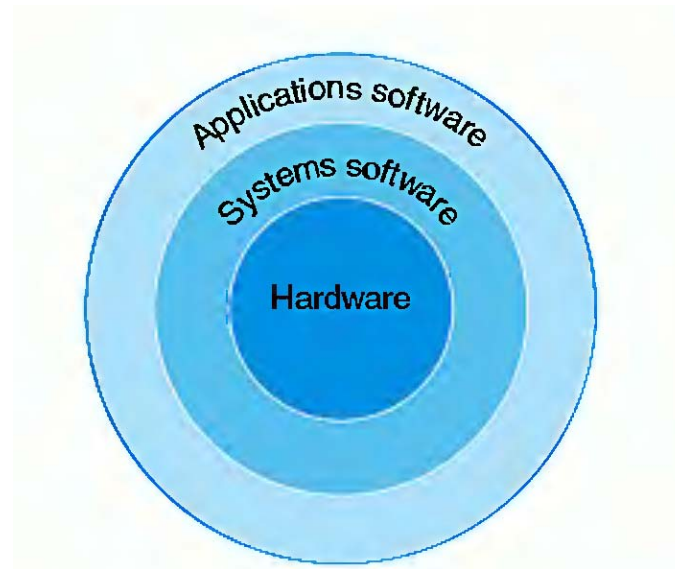
Levels of Abstraction



Source: Prof. Cheung's Course Notes (Imperial College, London)

Computer System = Hardware + System Software + Application Software

Source: H&P-3 (Hennesy & Patterson, 3rd Edition)



System Software: Operating System, Device Drivers, Loaders, Linkers, Compilers, Assemblers, Editors,

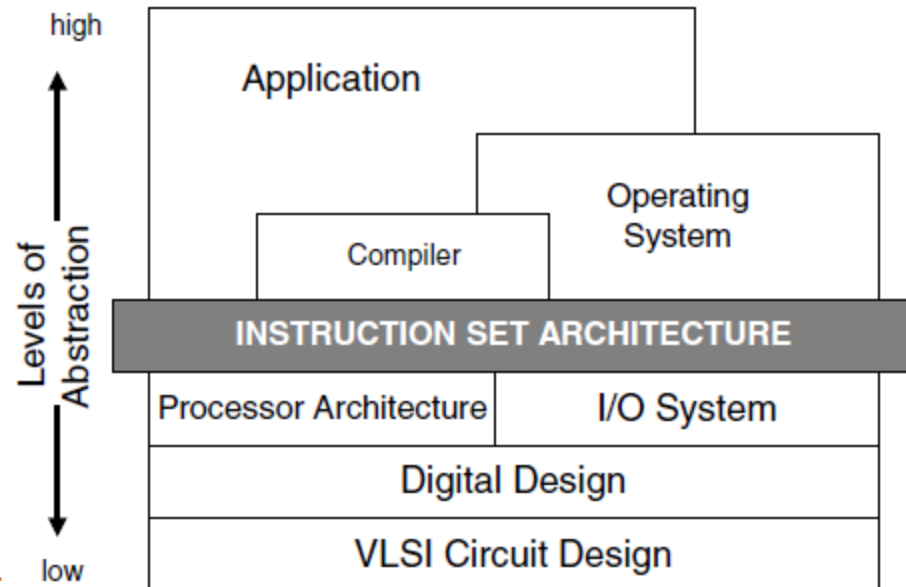
Application Software: Web browsers, user-specific applications,

Instruction Set Architecture (ISA)

- ❑ ISA is an abstraction for the Software to interface with the Hardware.
- ❑ **Advantage:** Multiple implemenations for the same ISA.
 - ❑ Ex: AMD Opteron 64 and Intel Pentium 4 are different Implementations of the ISA.

“... the attributes of a [computing] system as seen by the programmer, i.e. the conceptual structure and functional behavior, as distinct from the organization of the data flows and controls the logic design, and the physical implementation.”

➤ Amdahl, Blaaw, and Brooks, 1964



What does ISA consists of?

- Instruction Set
- Instruction Format
- Data Types and Data Structures (Integer, Floating Point, ...)
- Addressing Modes
- Exceptional Conditions
-

Technologies for Building Processors and Memories

A **transistor** is simply an on/off switch controlled by electricity.

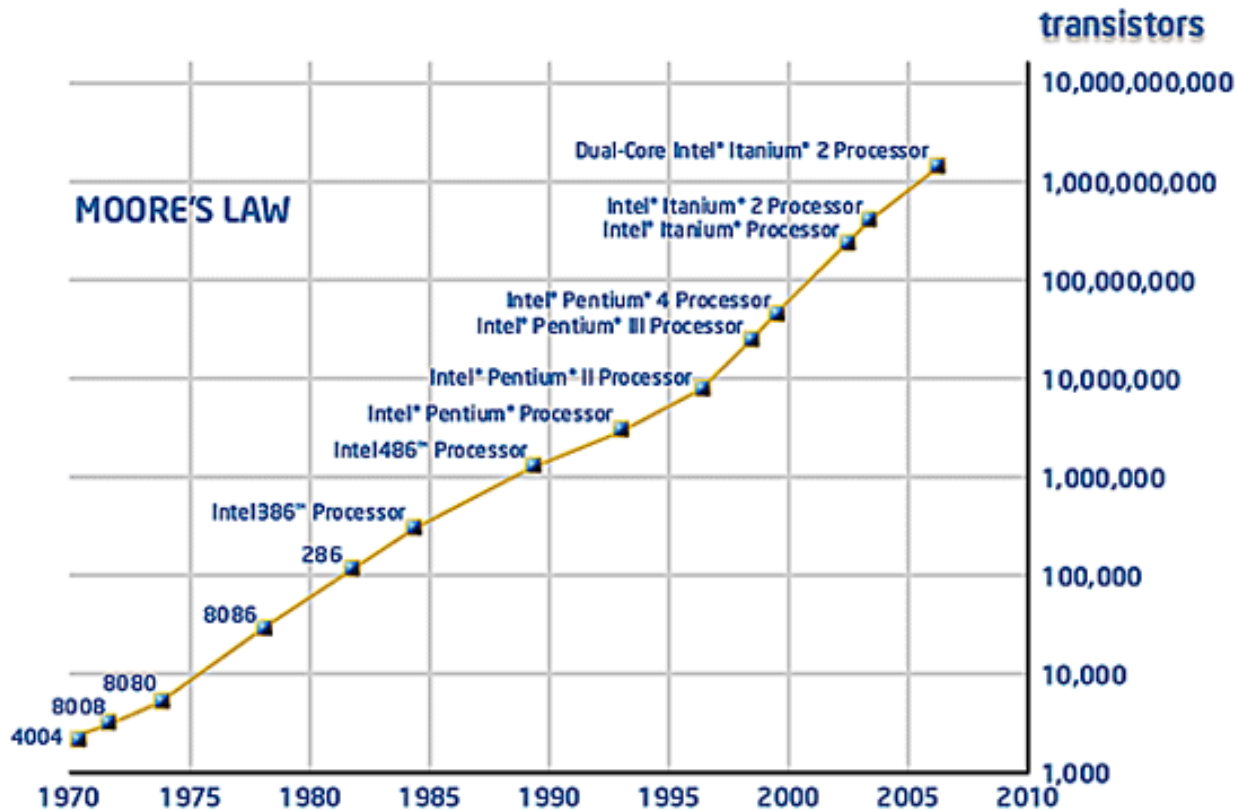
Year	Technology used in computers	Relative performance/unit cost
1951	Vacuum tube	1
1965	Transistor	35
1975	Integrated circuit	900
1995	Very large scale integrated circuit	2,400,000
2005	Ultra large scale integrated circuit	6,200,000,000

Source: H&P-3 (Hennesy & Patterson, 3rd Edition)

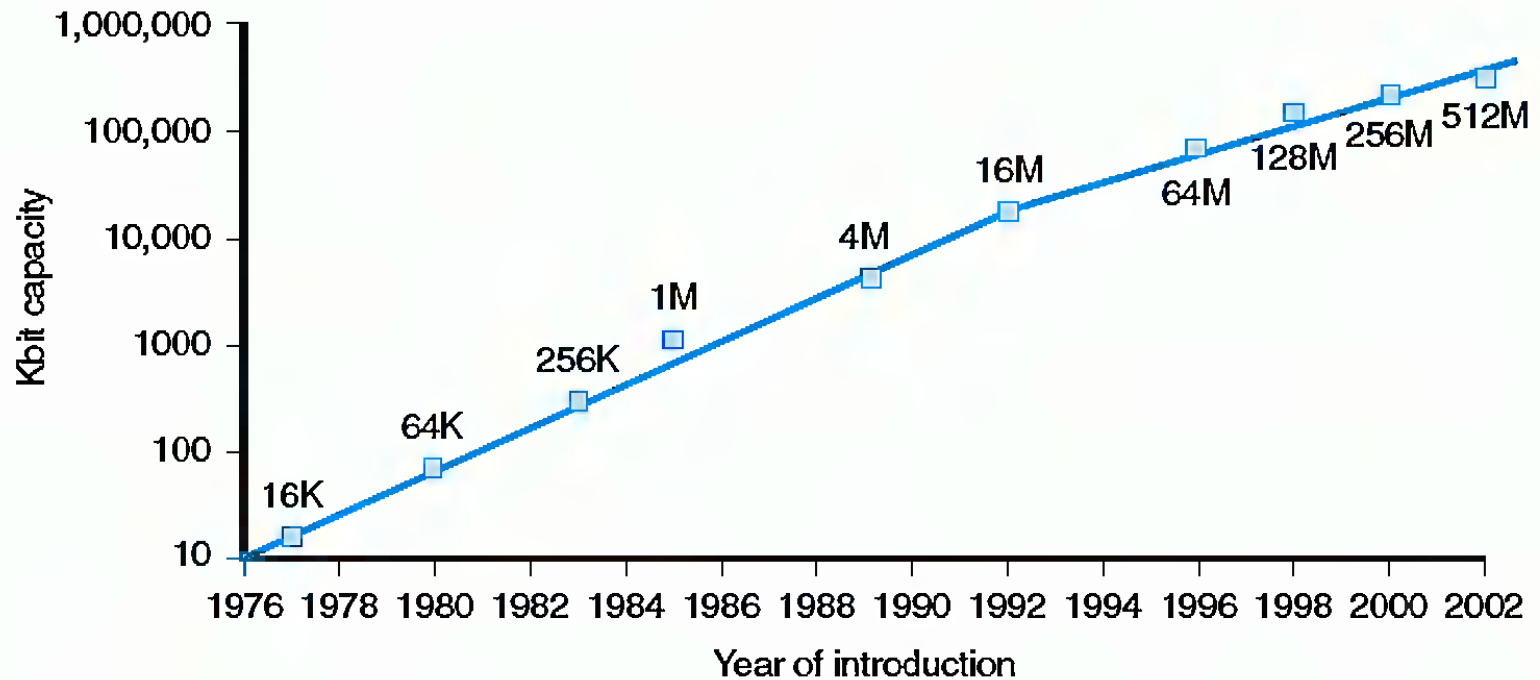
Moore's Law

Moore's law (1965): The number of transistors that can be placed inexpensively on an integrated circuit doubles every two years.

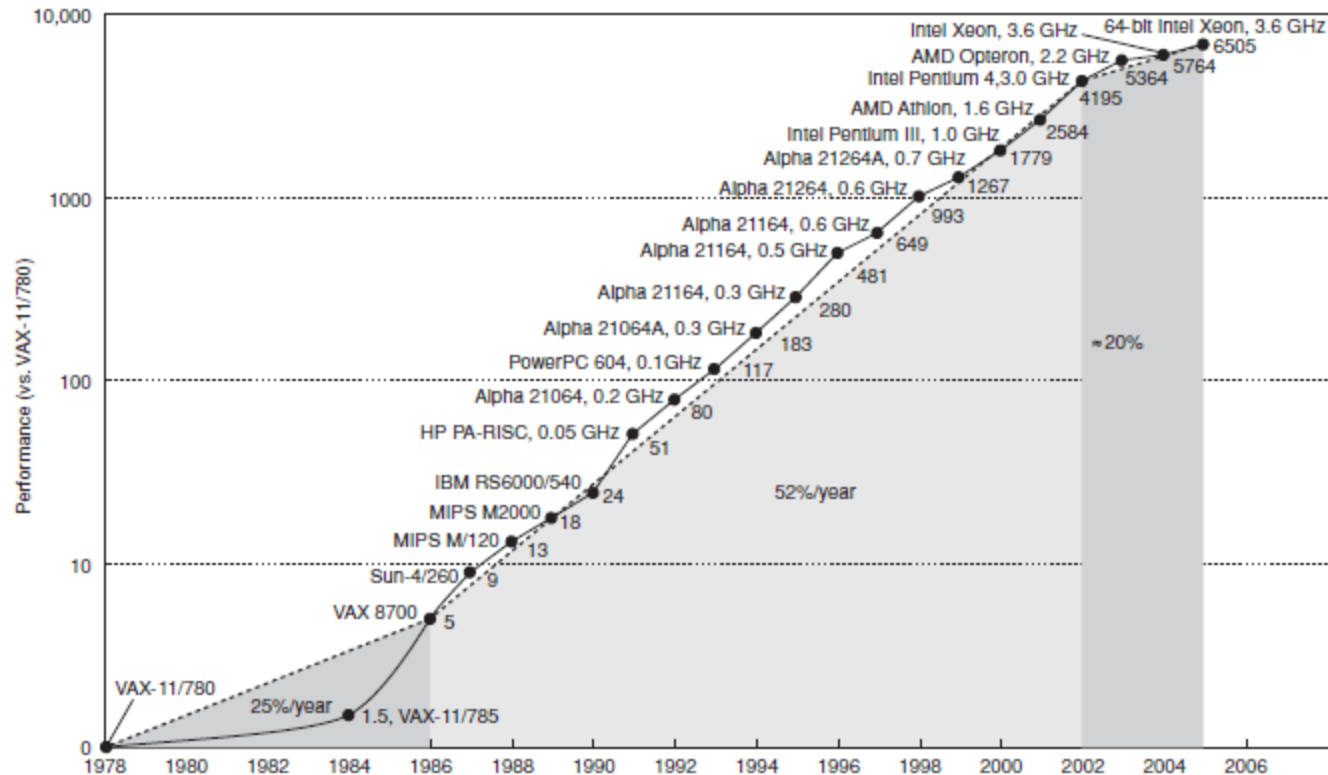
- Gordon Moore, Intel co-founder



Moore's Law and Memory

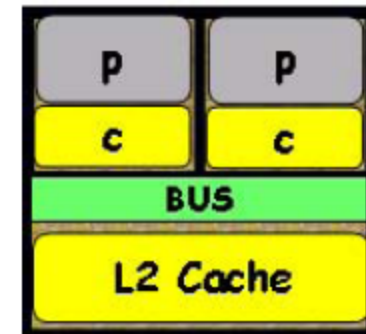
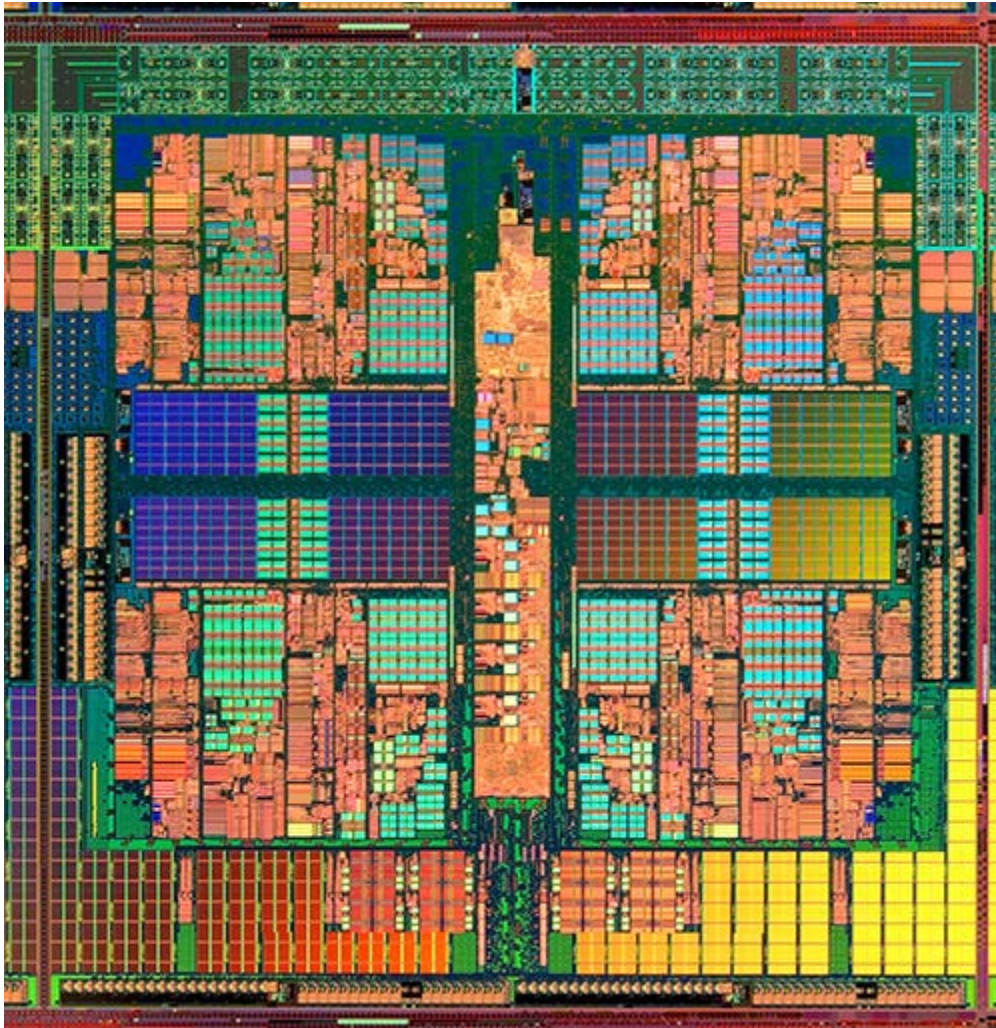


Performance Trends



- Between 1986 to 2002: Architectures exploiting ILP + Increasing Clock Speeds implied Improved Application Performance
- Since 2002: Power Wall + Memory + Diminishing returns from sophisticated architectures.

Dawn of Multi-core Era



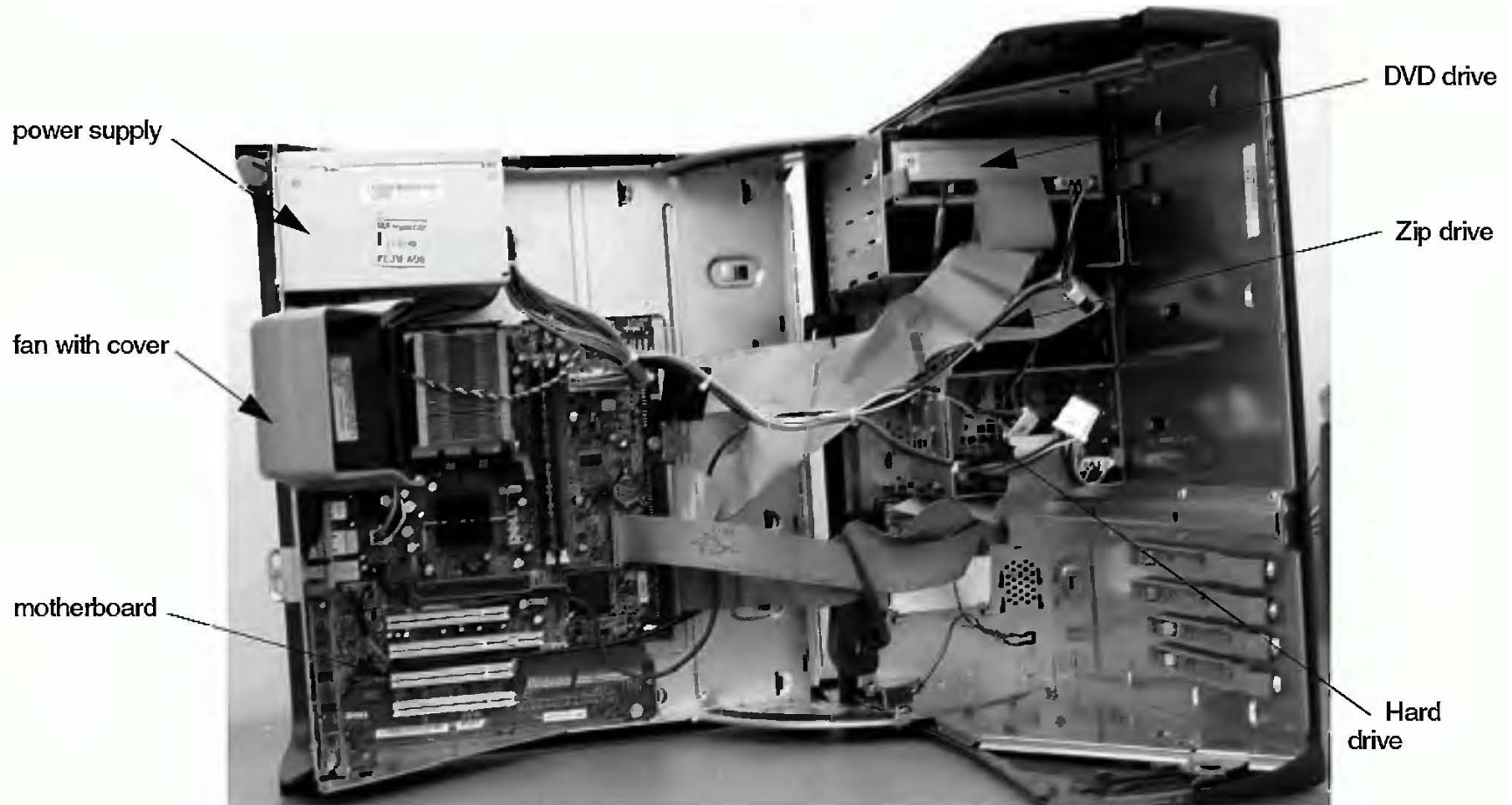
AMD Barcelona
Quadcore

Inside a Laptop



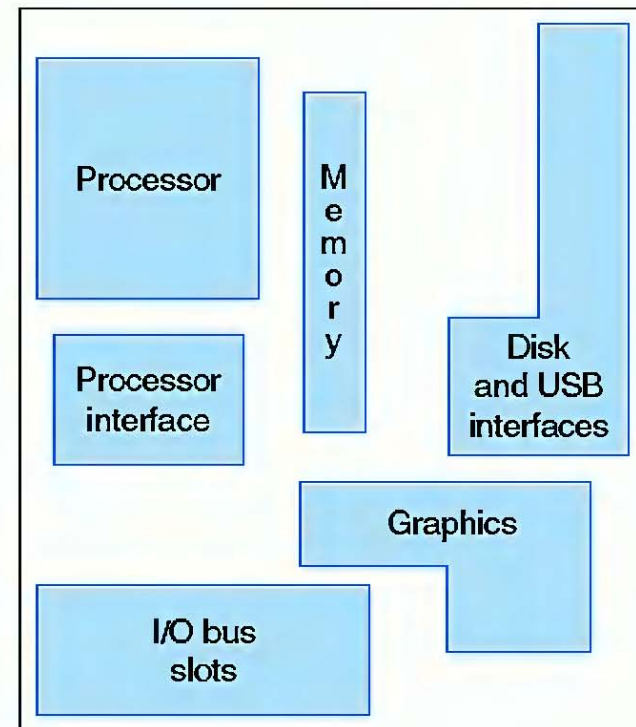
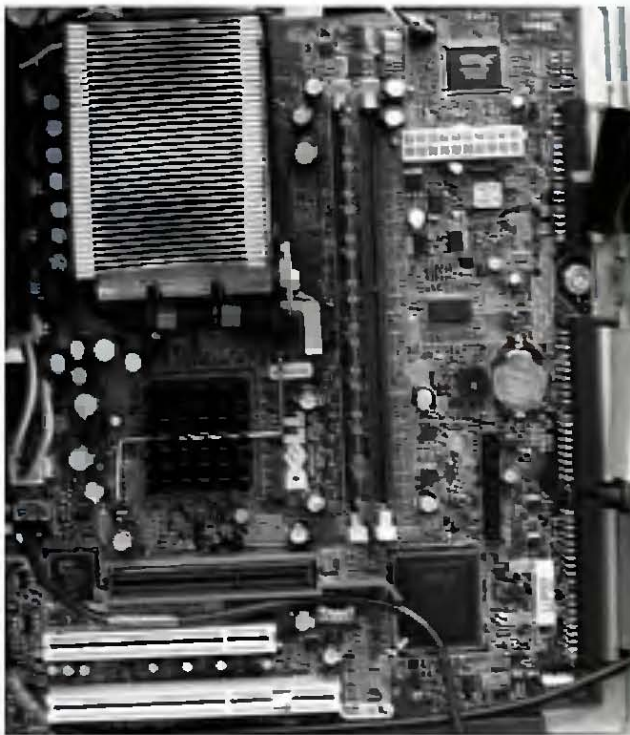
Source: howstuffworks.com

Inside a PC



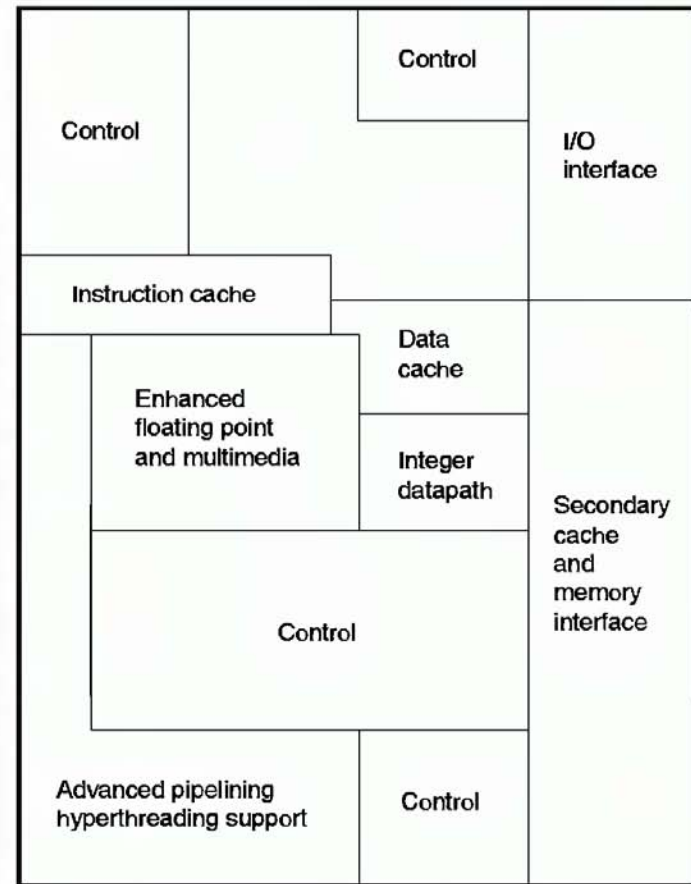
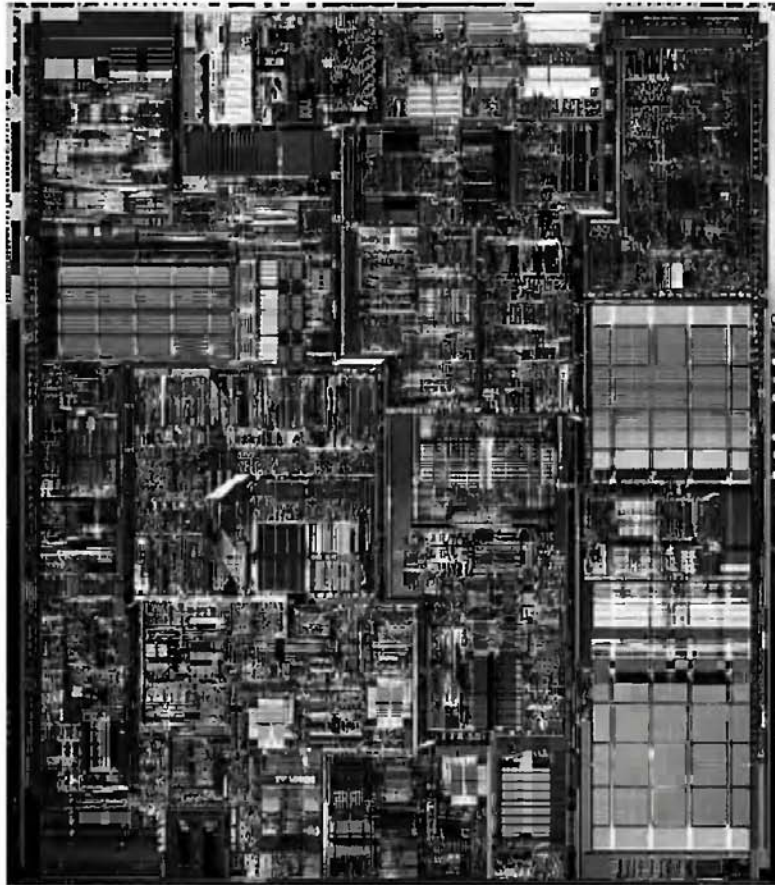
Source: H&P-3 (Hennesy & Patterson, 3rd Edition)

Close-up of Motherboard



Source: H&P-3 (Hennesy & Patterson, 3rd Edition)

Inside a Pentium 4 Processor



Source: H&P-3 (Hennesy & Patterson, 3rd Edition)

Course Outline



- ❑ Instruction Set Architecture of ARM and IA-32 processors.
- ❑ Computer Arithmetic
- ❑ Processor architecture and design
- ❑ Memory Hierarchies
- ❑ Input/Output
- ❑ Virtual Memory