ELEC 5200/6200

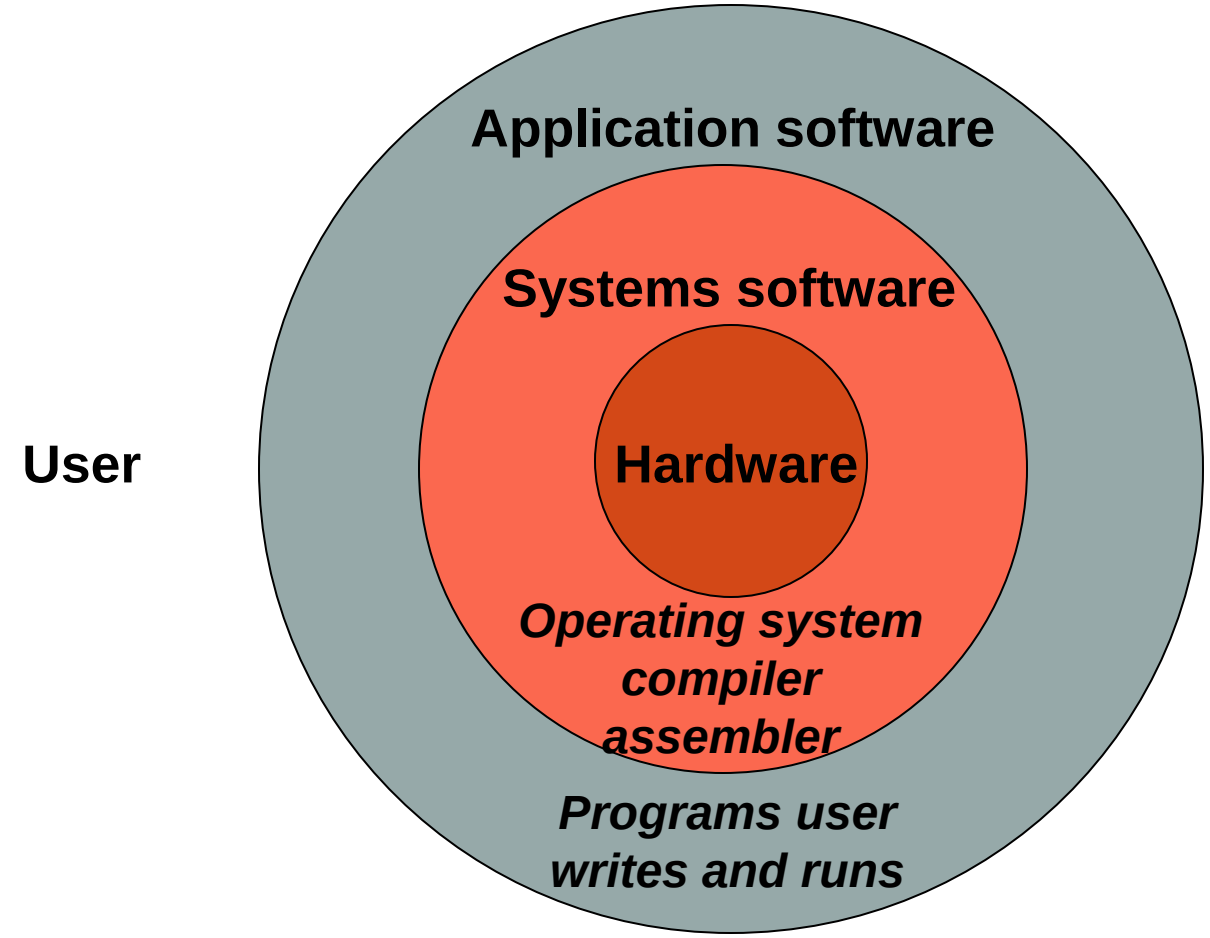
Computer Architecture & Design

Victor P. Nelson

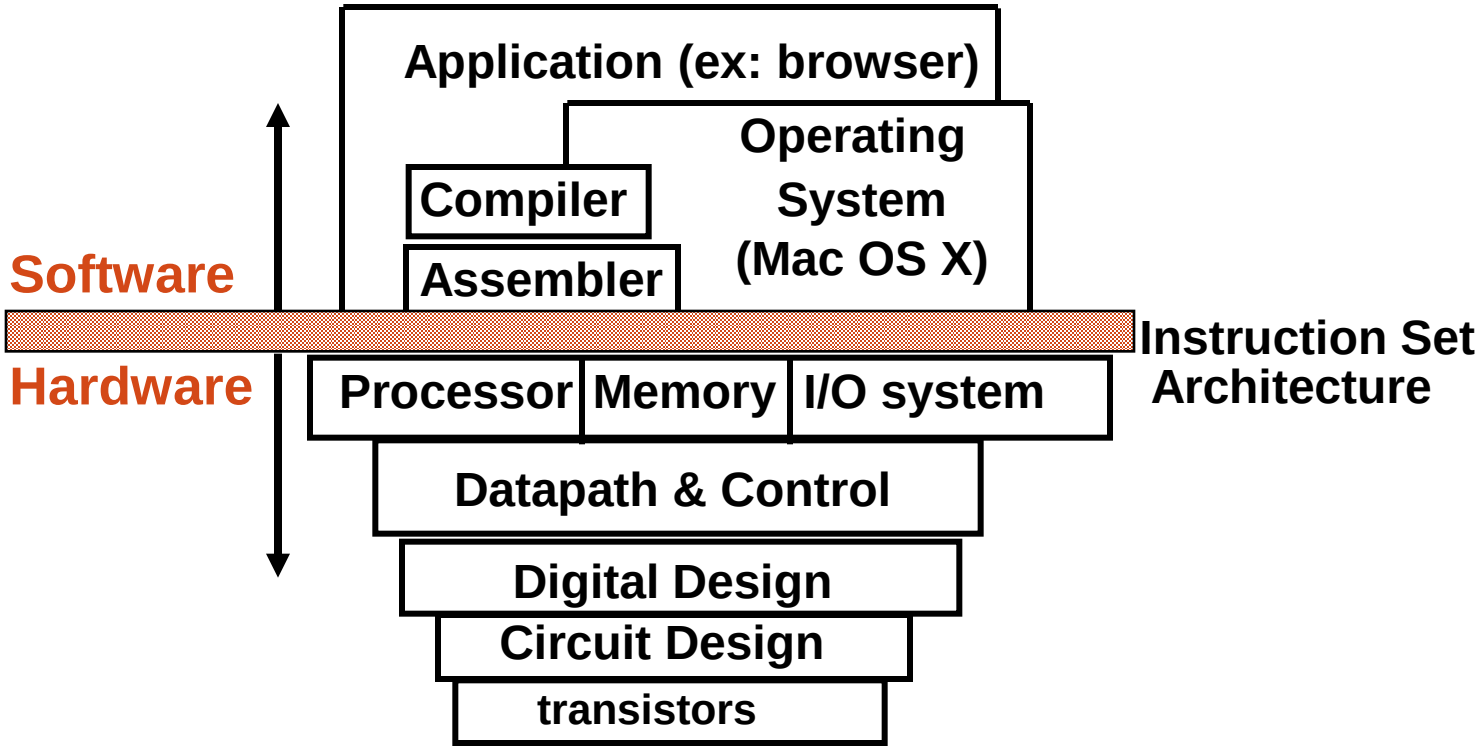
Broun 326

nelsovp@auburn.edu

The Concept of a Computer



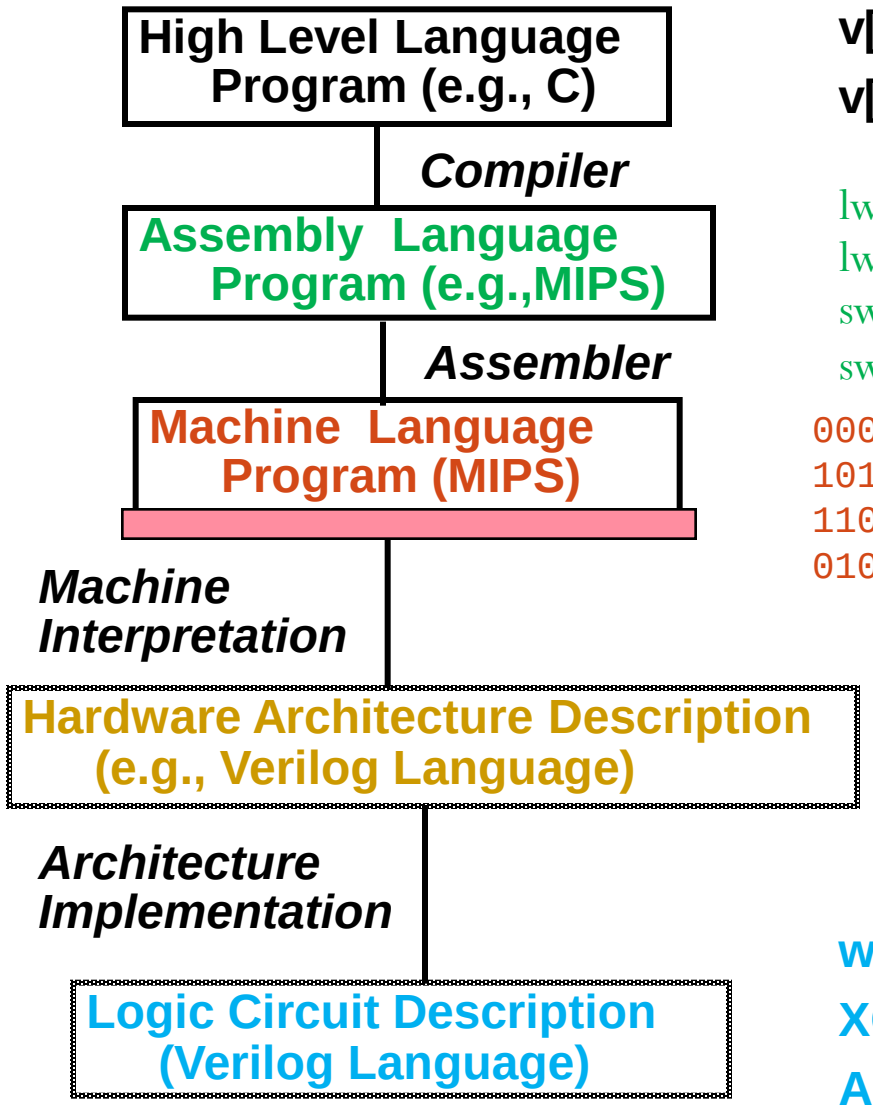
What are “Machine Structures”?



* Coordination of many

levels (layers) of abstraction

Levels of Representation




```
temp = v[k];
v[k] = v[k+1];
v[k+1] = temp;
```

```
lw   $t0, 0($2)
lw   $t1, 4($2)
sw   $t1, 0($2)
sw   $t0, 4($2)
```

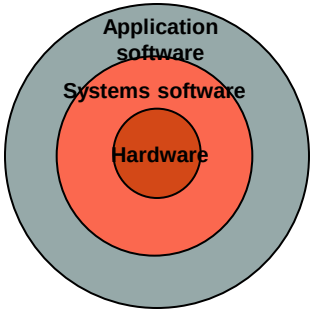
```
0000 1001 1100 0110 1010 1111 0101 1000
1010 1111 0101 1000 0000 1001 1100 0110
1100 0110 1010 1111 0101 1000 0000 1001
0101 1000 0000 1001 1100 0110 1010 1111
```

```
wire [31:0] dataBus;
regFile registers (databus);
ALU ALUBlock (inA, inB, databus);
```

```
wire w0;
XOR (w0, a, b);
AND (s, w0, a);
```

Instruction Set Architecture (ISA)

- A set of assembly language instructions (ISA) provides a link between software and hardware.
- Given an instruction set, software programmers and hardware engineers work more or less independently.
- ISA is designed to extract the most performance out of the available hardware technology.



ISA

- Defines registers
- Defines data transfer modes between registers, memory and I/O
- Types of ISA: RISC, CISC, VLIW, Superscalar
- Examples:
  - IBM370/X86/Pentium/K6 (CISC)
  - PowerPC (Superscalar)
  - Alpha (Superscalar)
  - MIPS (RISC and Superscalar)
  - Sparc (RISC), UltraSparc (Superscalar)
  - ARM (RISC, many versions)

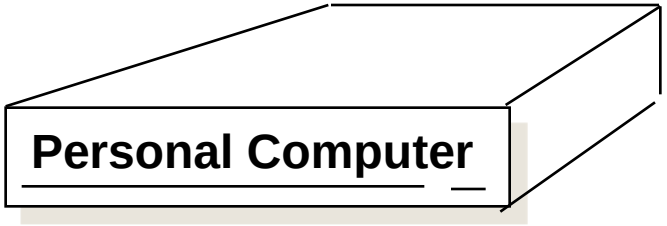
Computer *Architecture*

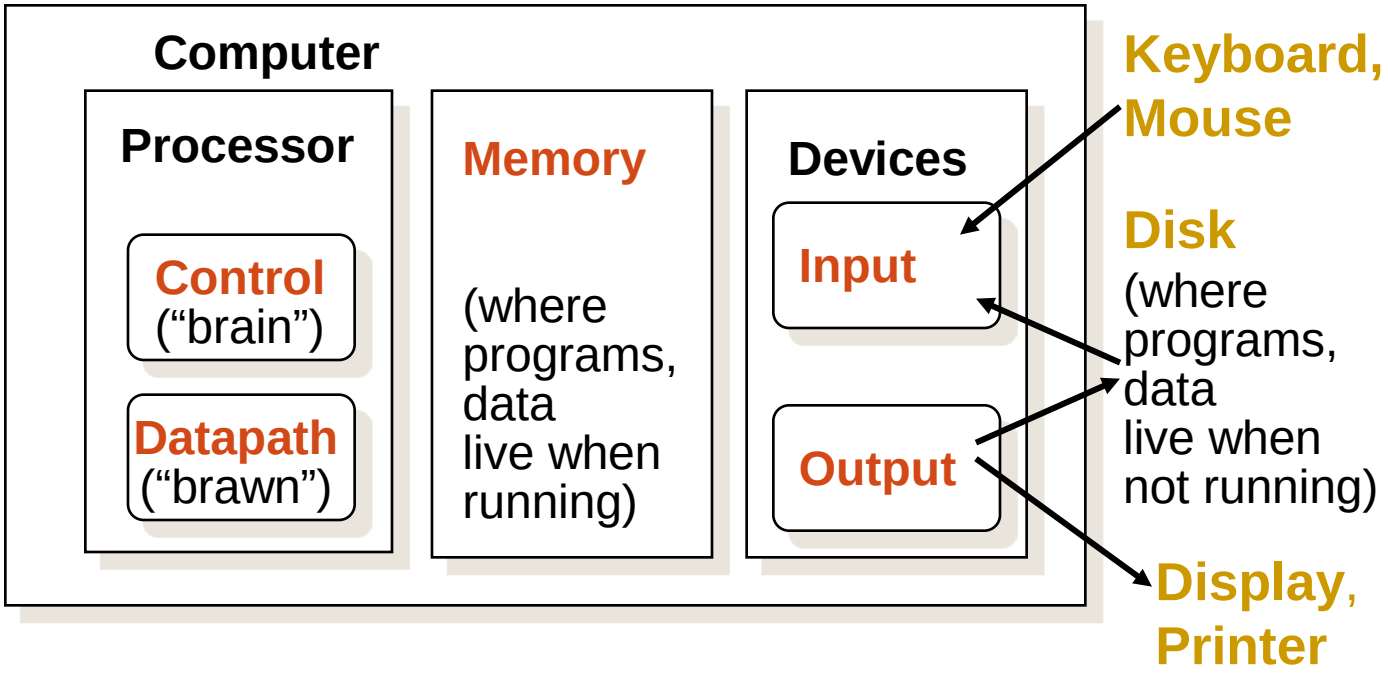
- Architecture: System attributes that have a direct impact on the logical execution of a program
- Architecture is visible to a programmer:
  - Instruction set
  - Data representation
  - I/O mechanisms
  - Memory addressing

Computer *Organization*

- Organization: Physical details that are transparent to a programmer, such as
  - Hardware implementation of an instruction
  - Control signals
  - Memory technology used
- Example: System/370 architecture has been used in many IBM computers, which widely differ in their organization.

5 components of any Computer





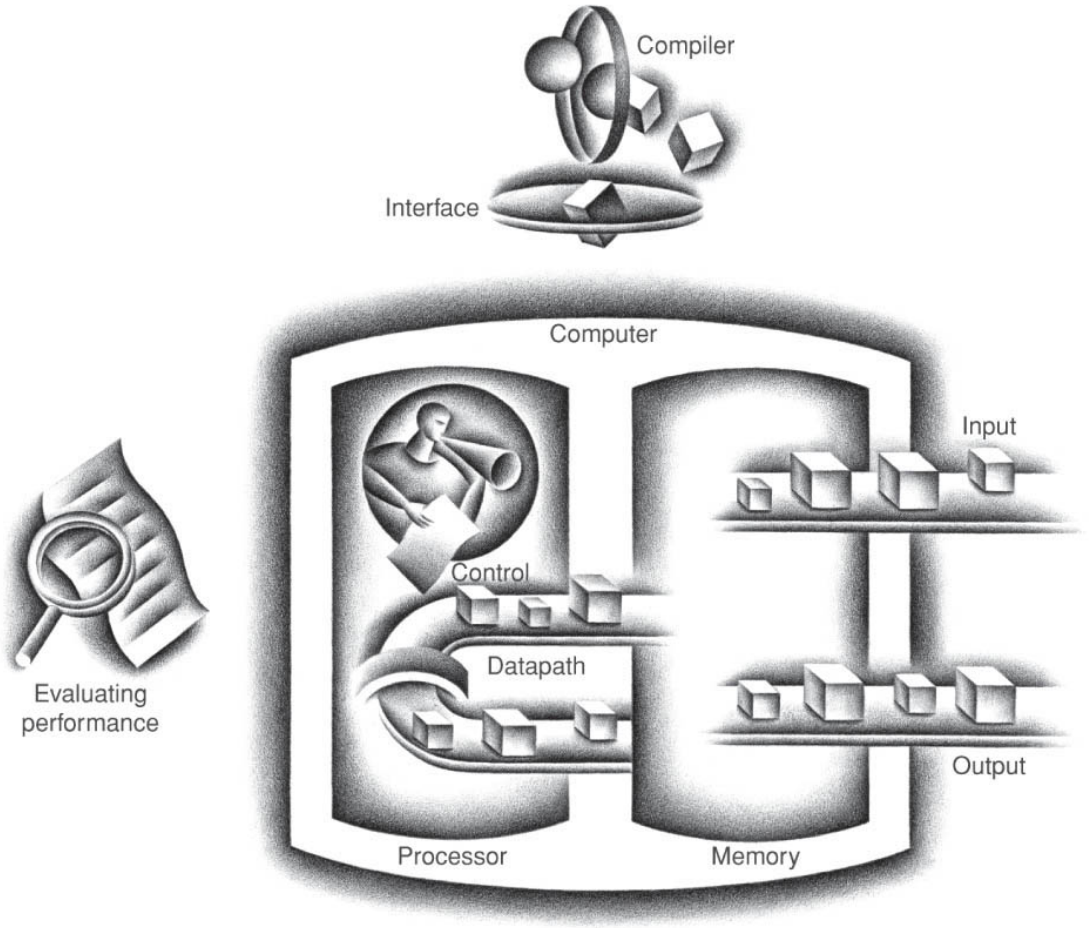


FIGURE 1.4 The organization of a computer, showing the fi ve classic components. The processor gets instructions and data from memory. Input writes data to memory, and output reads data from memory. Control sends the signals that determine the operations of the datapath, memory, input, and output.

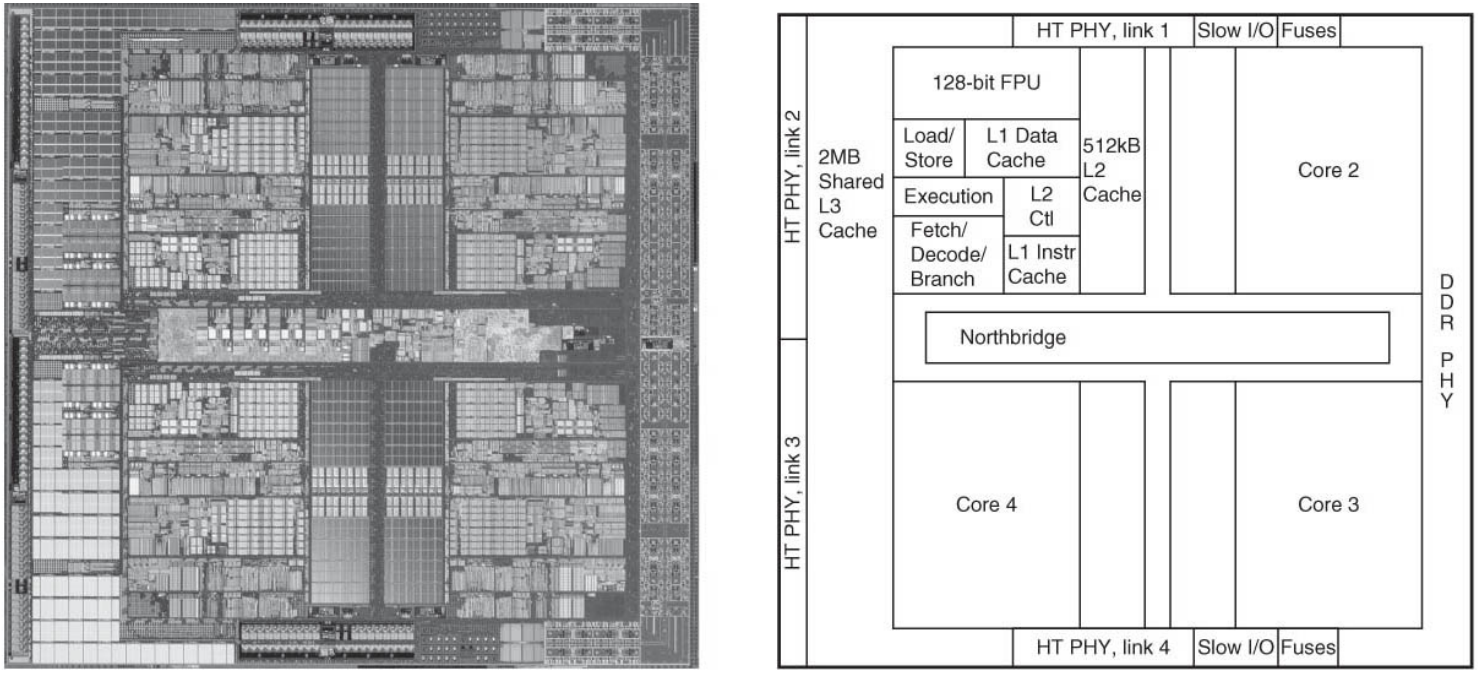


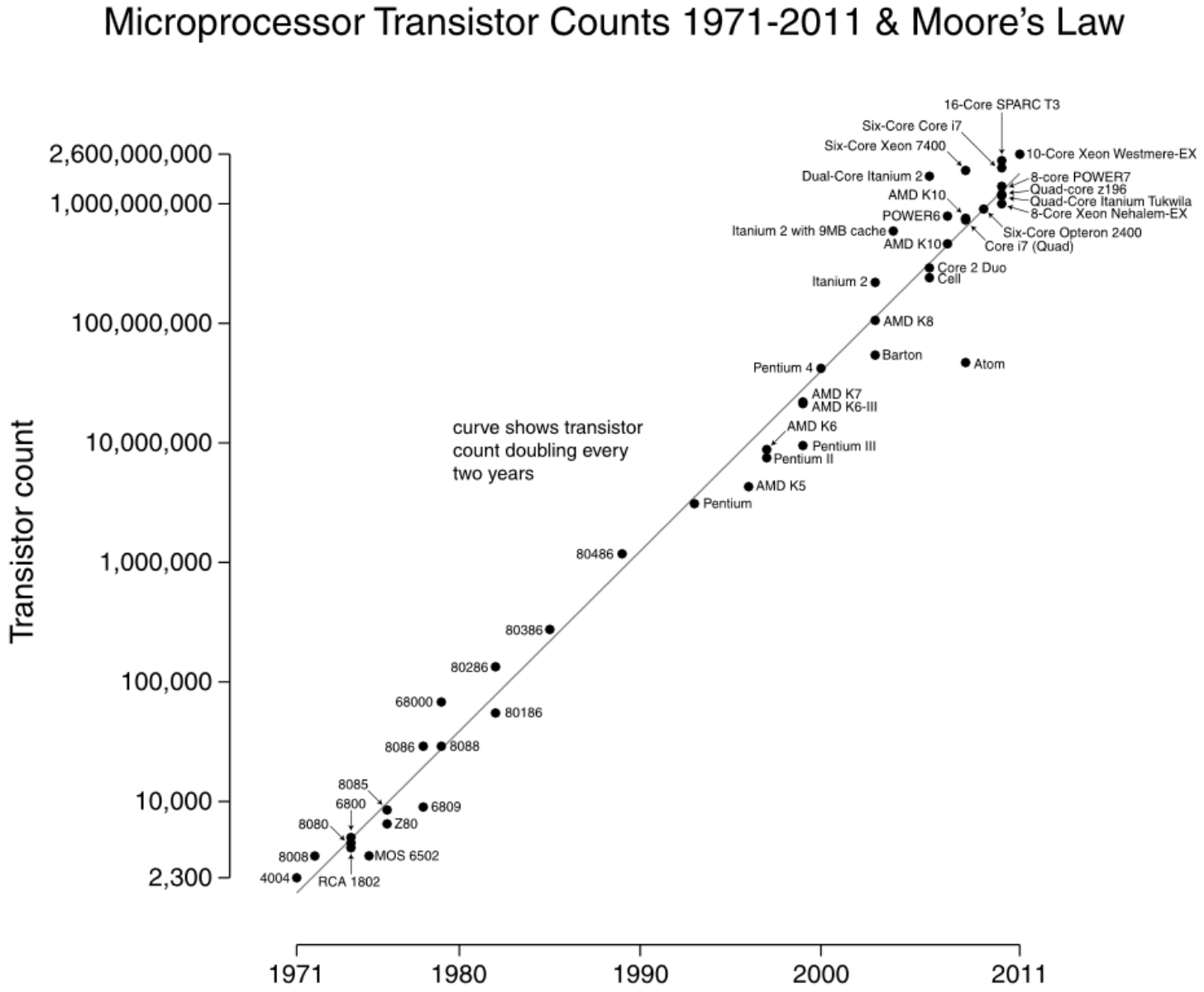
FIGURE 1.9 Inside the AMD Barcelona microprocessor. The left-hand side is a microphotograph of the AMD Barcelona processor chip, and the right-hand side shows the major blocks in the processor. This chip has four processors or “cores”. The microprocessor in the laptop in Figure 1.7 has two cores per chip, called an Intel Core 2 Duo.

Relative performance per unit cost

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

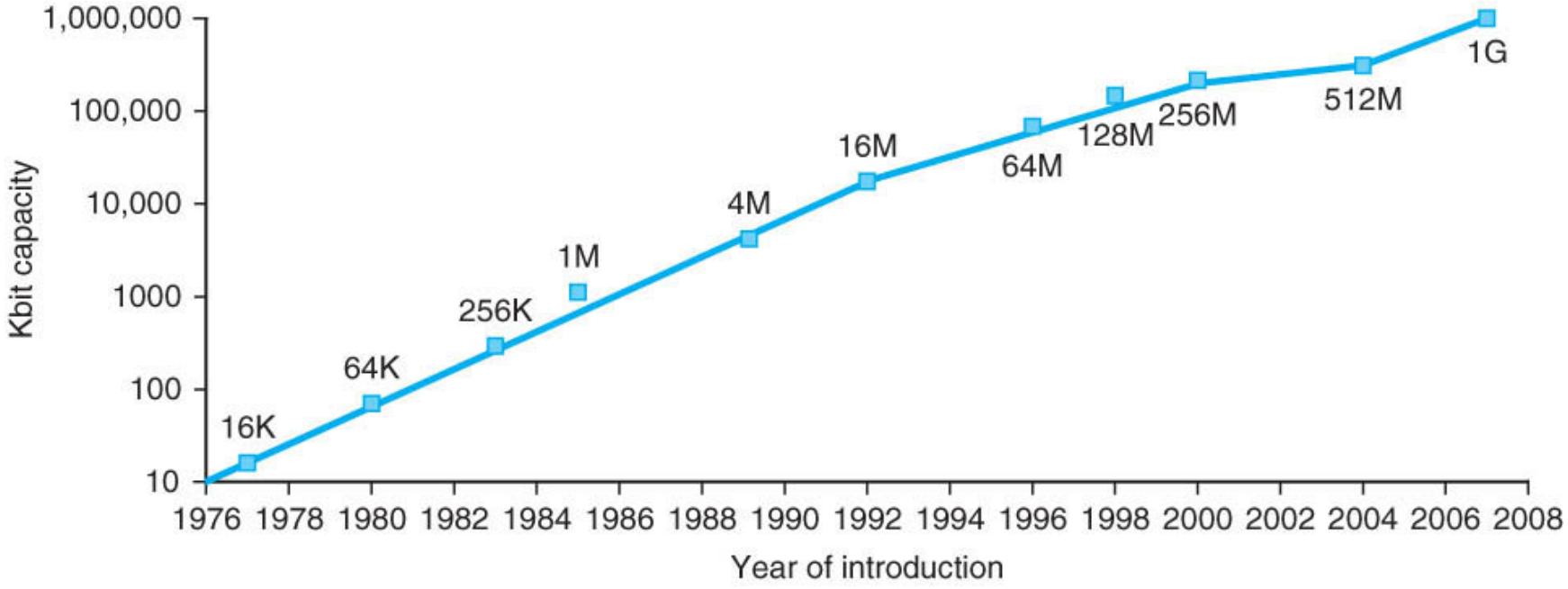
FIGURE 1.11 Relative performance per unit cost of technologies used in computers over time. Source: Computer Museum, Boston, with 2005 extrapolated by the authors. See Section 1.10 on the CD.

The Computer Museum (Boston, MA) http://www.computerhistory.org



http://commons.wikimedia.org/wiki/File:Transistor_Count_and_Moore%27s_Law_-_2011.svg

DRAM capacity vs time

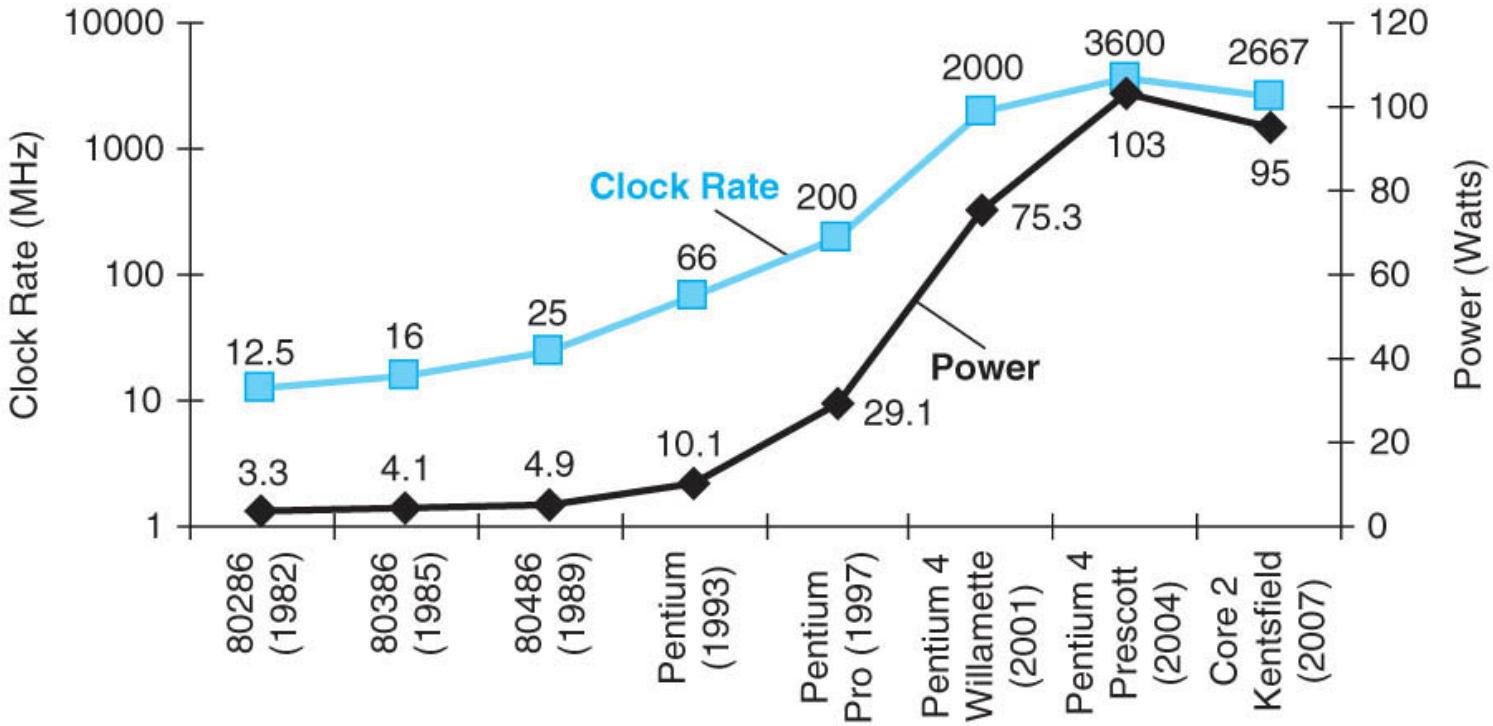


Measuring performance

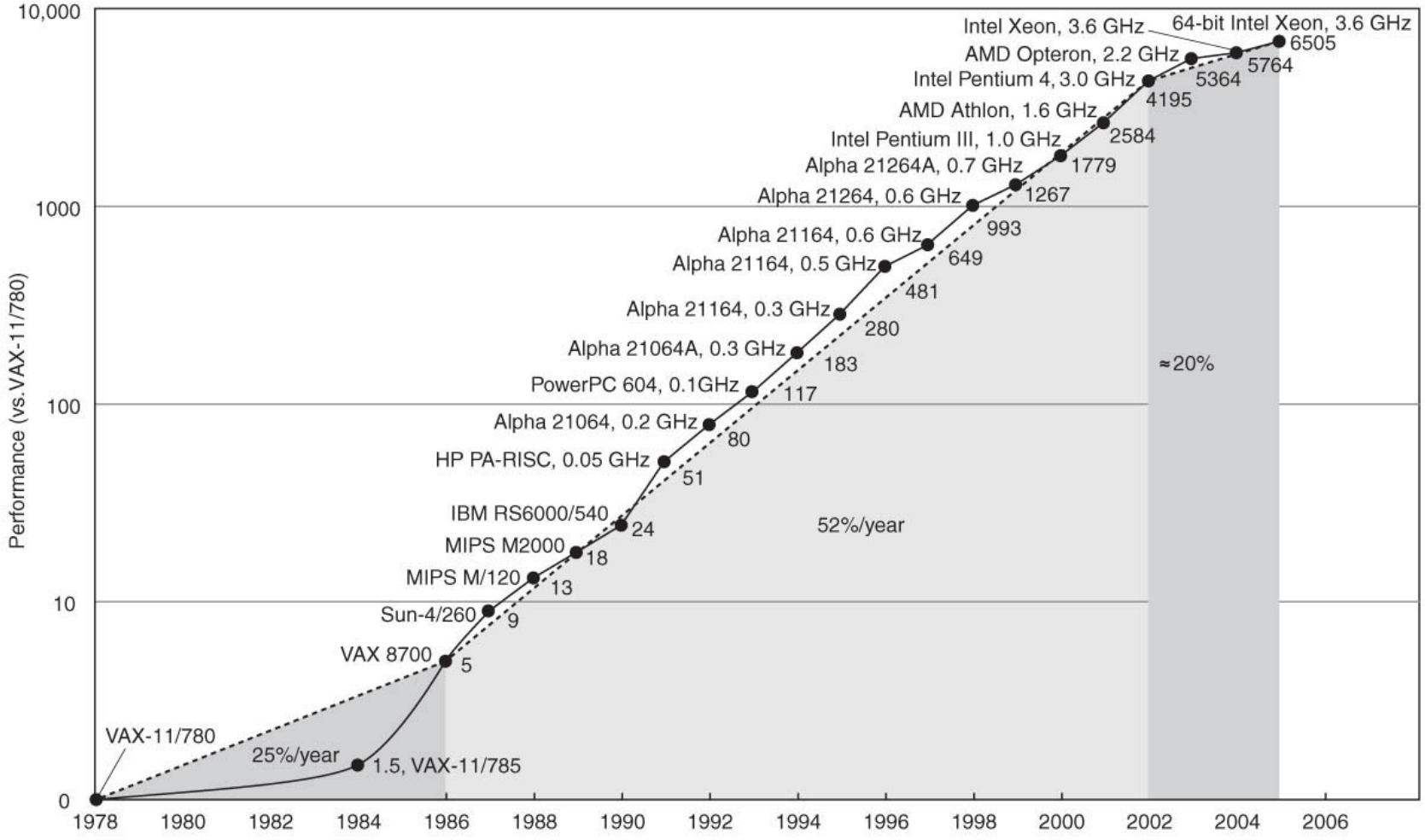
Components of performance	Units of measure
CPU execution time for a program	Seconds for the program
Instruction count	Instructions executed for the program
Clock cycles per instruction (CPI)	Average number of clock cycles per instruction
Clock cycle time	Seconds per clock cycle

$$T_{execution} = (\text{Instruction count}) \times (\text{CPI}) \times (\text{Clock cycle time})$$

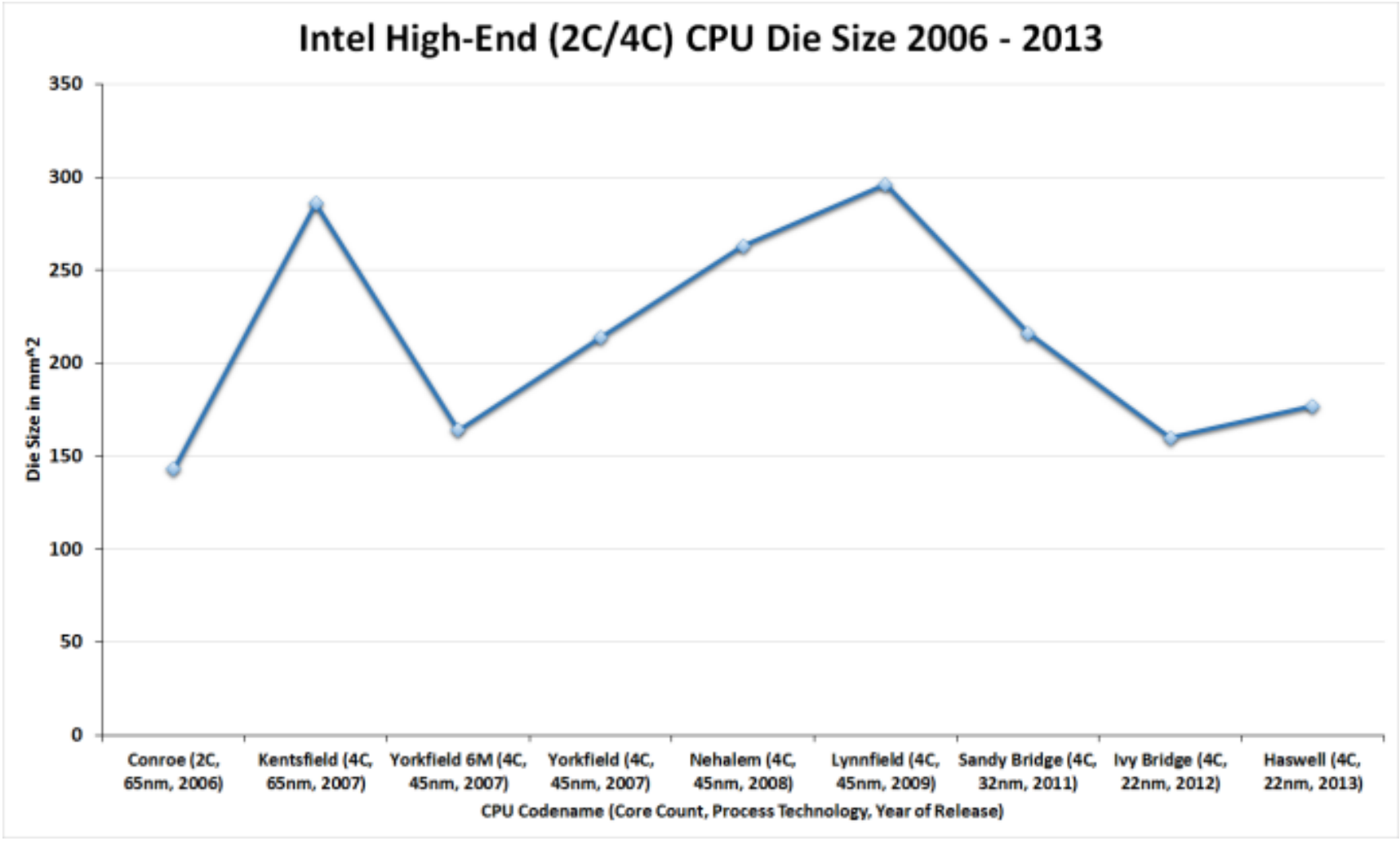
Clock rate and power for Intel x86 uPs



Processor performance growth



Intel CPU die size and technology



http://www.anandtech.com/show/7003/the-haswell-review-intel-core-i74770k-i54560k-tested/5

Computer Technology - Dramatic Change!

- State-of-the-art PC when you graduate:
  (at least…) *- From several years ago – what are they now?*
  - Processor clock speed: 5000 MegaHertz (5.0 GigaHertz)
  - Memory capacity: 4000 MegaBytes (4.0 GigaBytes)
  - Disk capacity: 2000 GigaBytes (2.0 TeraBytes)
  - New units! Mega => Giga, Giga => Tera

(Kilo, Mega, Giga, Tera, Peta, Exa, Zetta, Yotta = 10^{24})

Research and Developments of Continuing Interest

- Instruction level parallelism (ILP)
- Multi-core processors and Chip multi-processing (CMP)
- Energy efficiency and low power design
- Embedded systems
- Network processing