Chapter 1
Computer Abstractions and Technology

Impact of Computer Technology

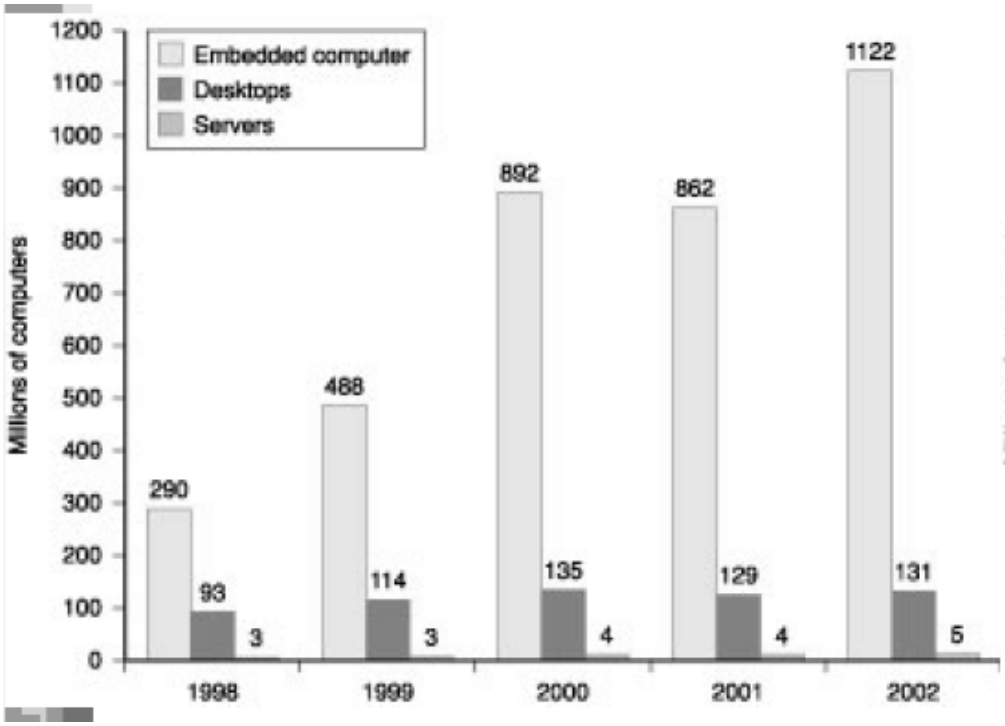
- Computer price is going down for each year
- And the computer industry is a stable industry
- However, its impact is just started (social impact)
  - ATM
  - Computers in automobiles
  - Laptop computer
  - Human genome project
  - WWW
  - More “computer science fiction”

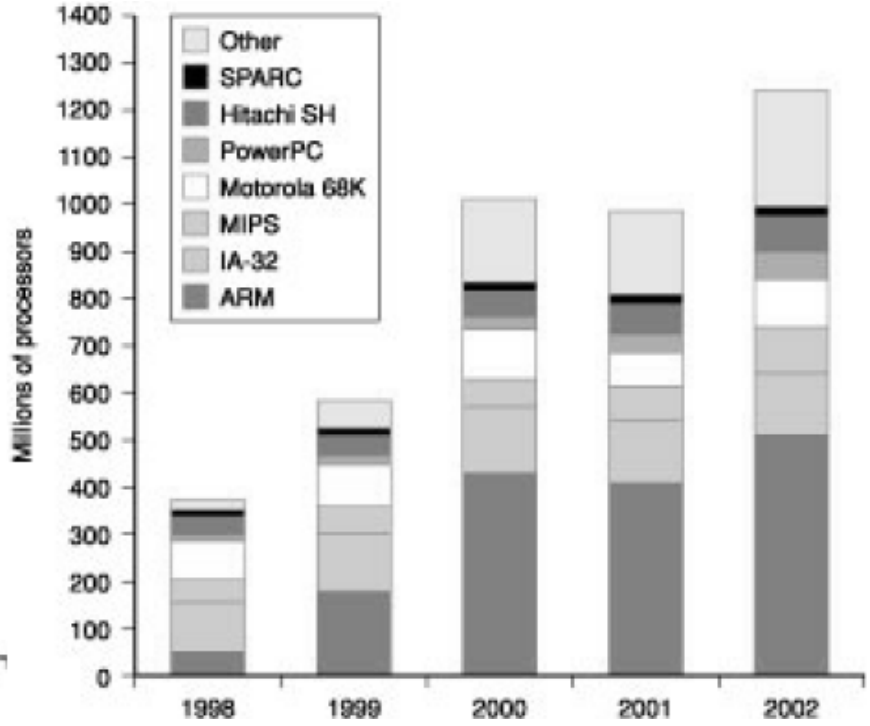
Classes of Computing Applications and Their Characteristics

- Desktop computer
  - One of the Largest market of the computer
  - Emphasize delivering good performance to a single user at low cost and usually are used to execute third party software
- Servers
  - Mainframes, minicomputers, supercomputer
  - To carry large workloads, e.g. scientific or engineering or web
  - High performance, and dependability
- Embedded computers
  - Largest class of computers
  - PDA, cellular phone, game console, digital TV
  - Designed to run one or one set of related applications
  - Maximum performance with lowest cost or power

What's the difference of these three?
And how it affect the computer design?

Classes of Computing Applications and Their Characteristics

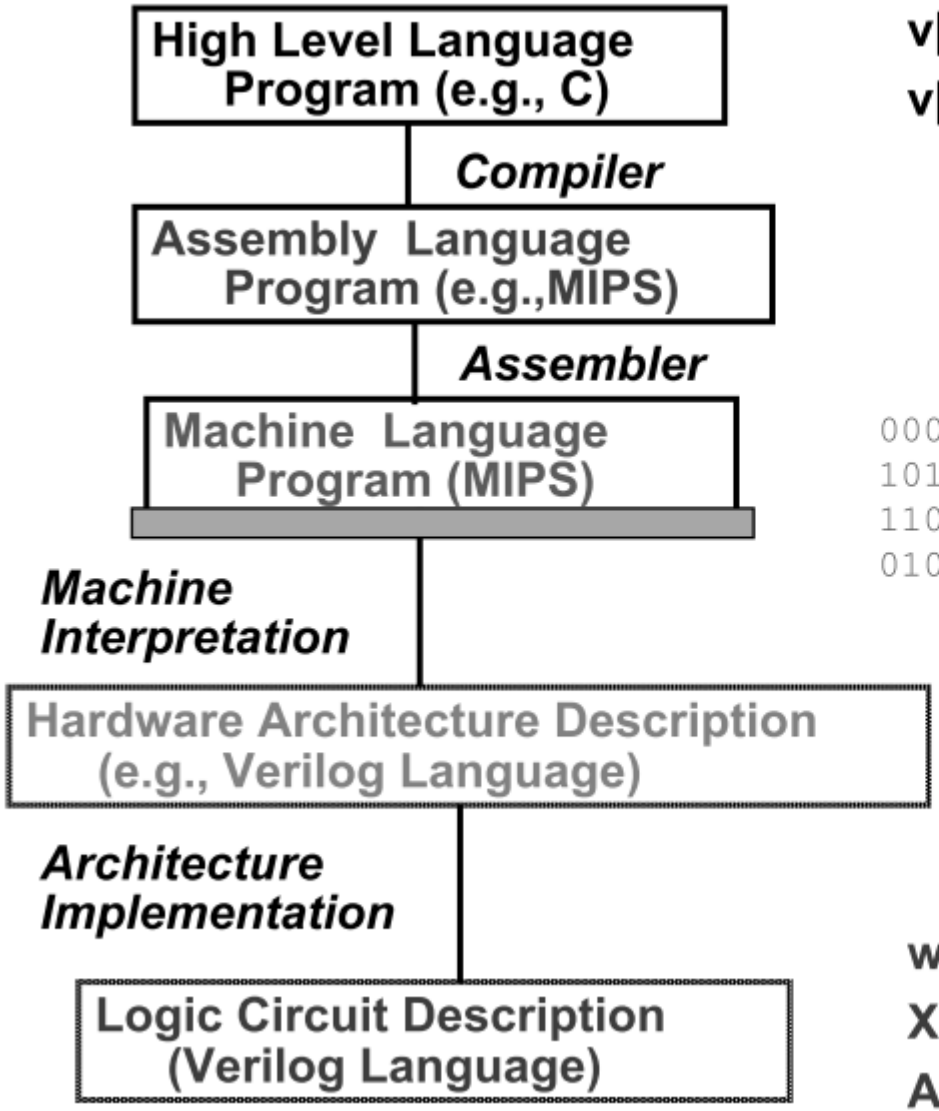




Below Your Program

- Application software
  - MS office
  - Web browser
- System software
  - Compiler
    - Translate high level language into hardware executable language
  - OS
    - Manage the computer resource for the benefits of the program

Levels of Representation
From High Level Language to Hardware Language




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

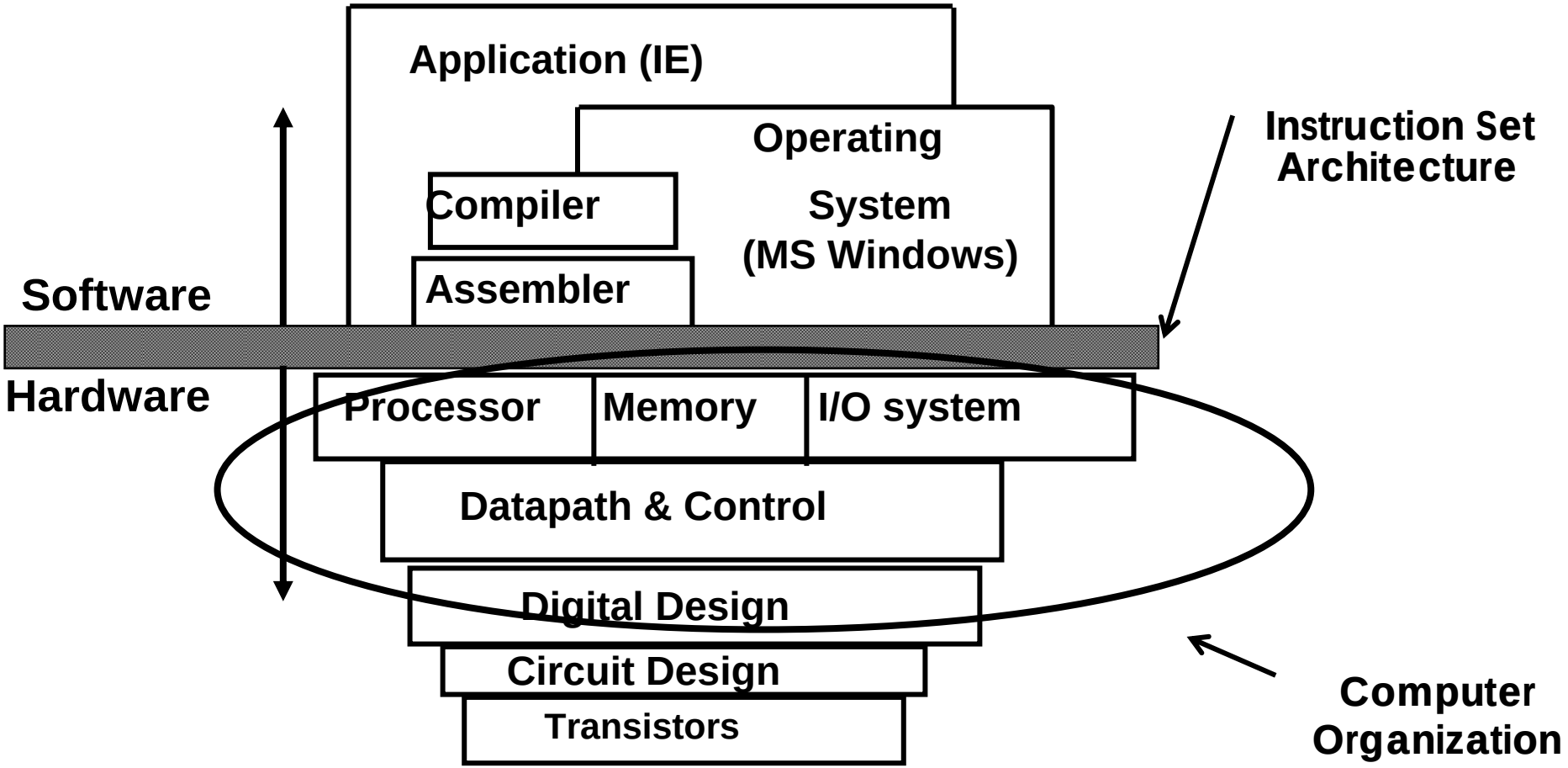
```
lw   $t0, 0($2)
lw   $t1, 4($2)
sw   $t1, 0($2)
sw   $t0, 4($2)
```

```
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);
```

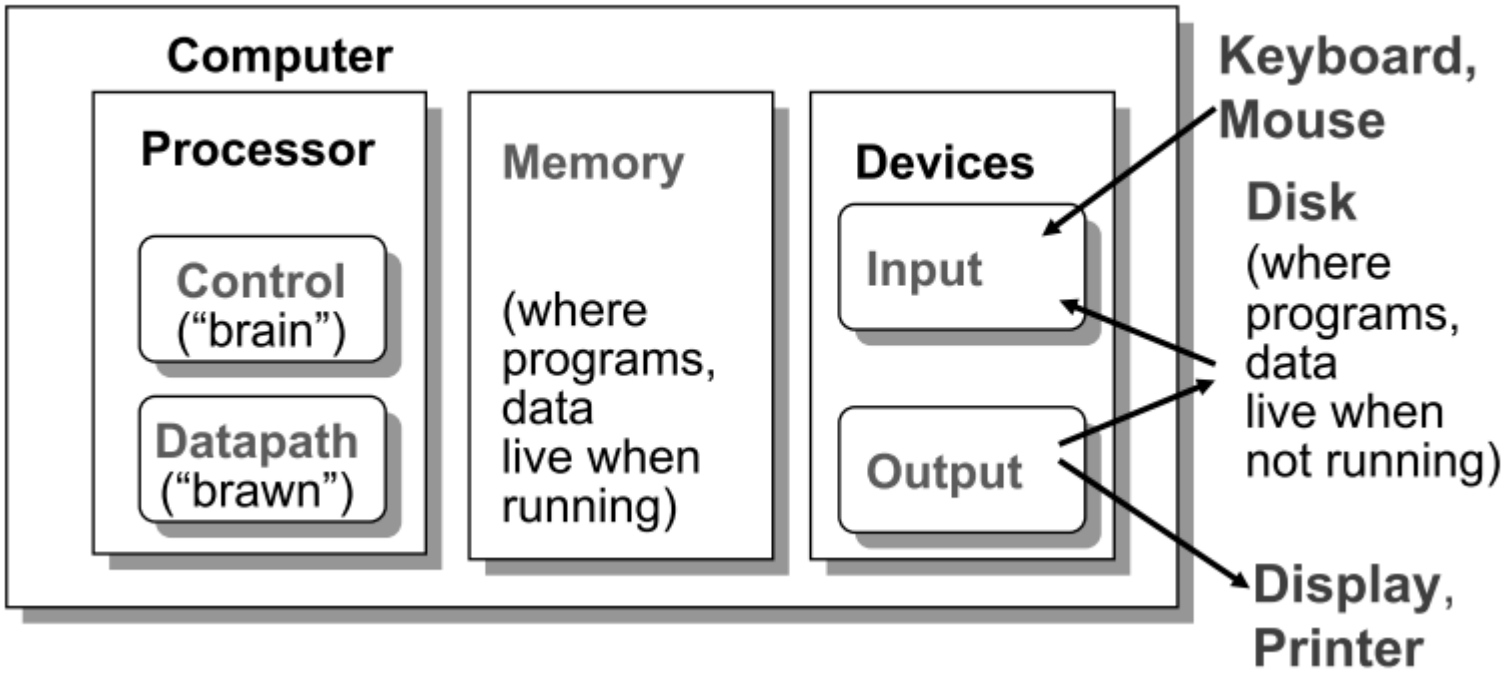
Computer Organization

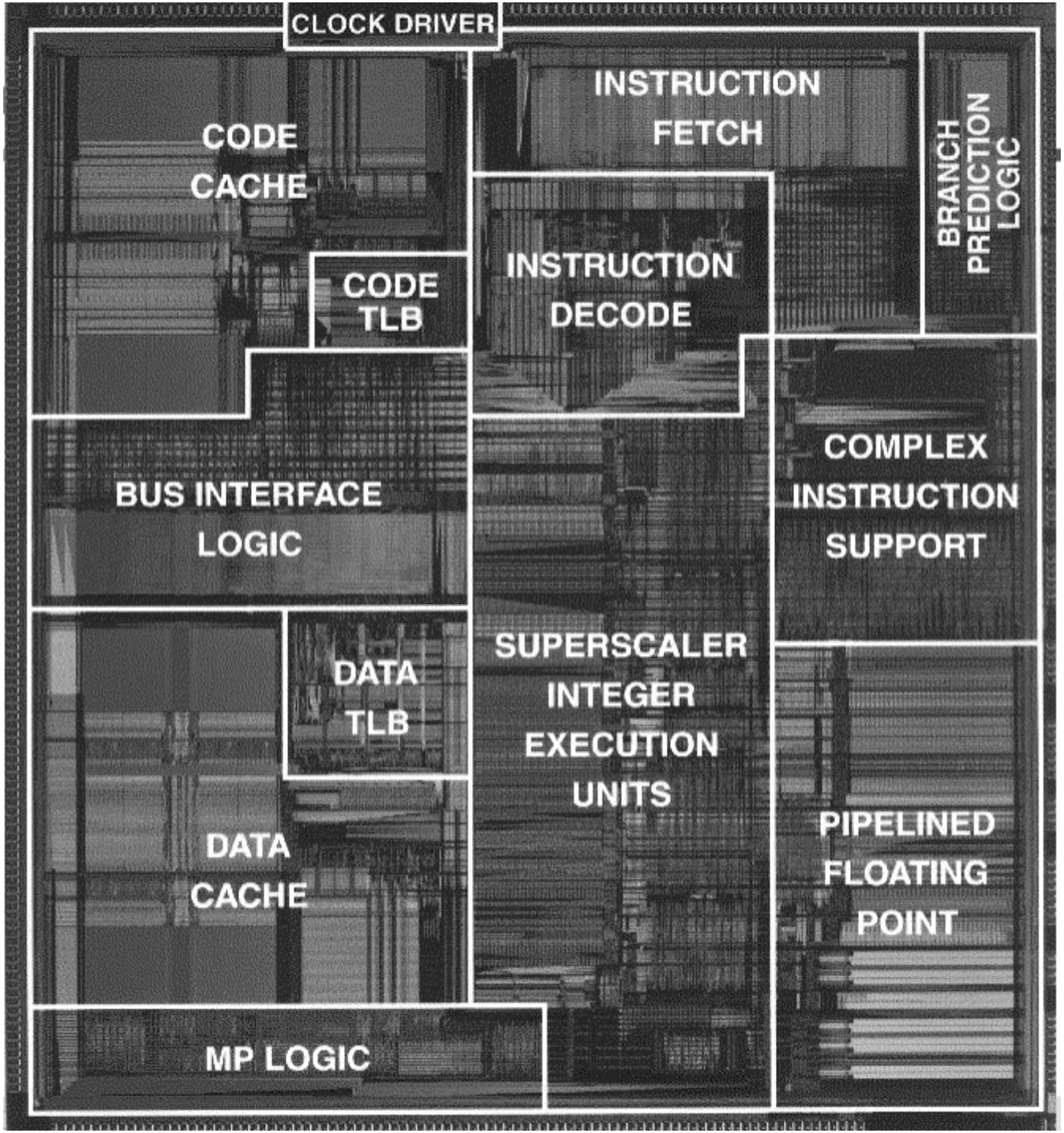


Instruction Set Architecture

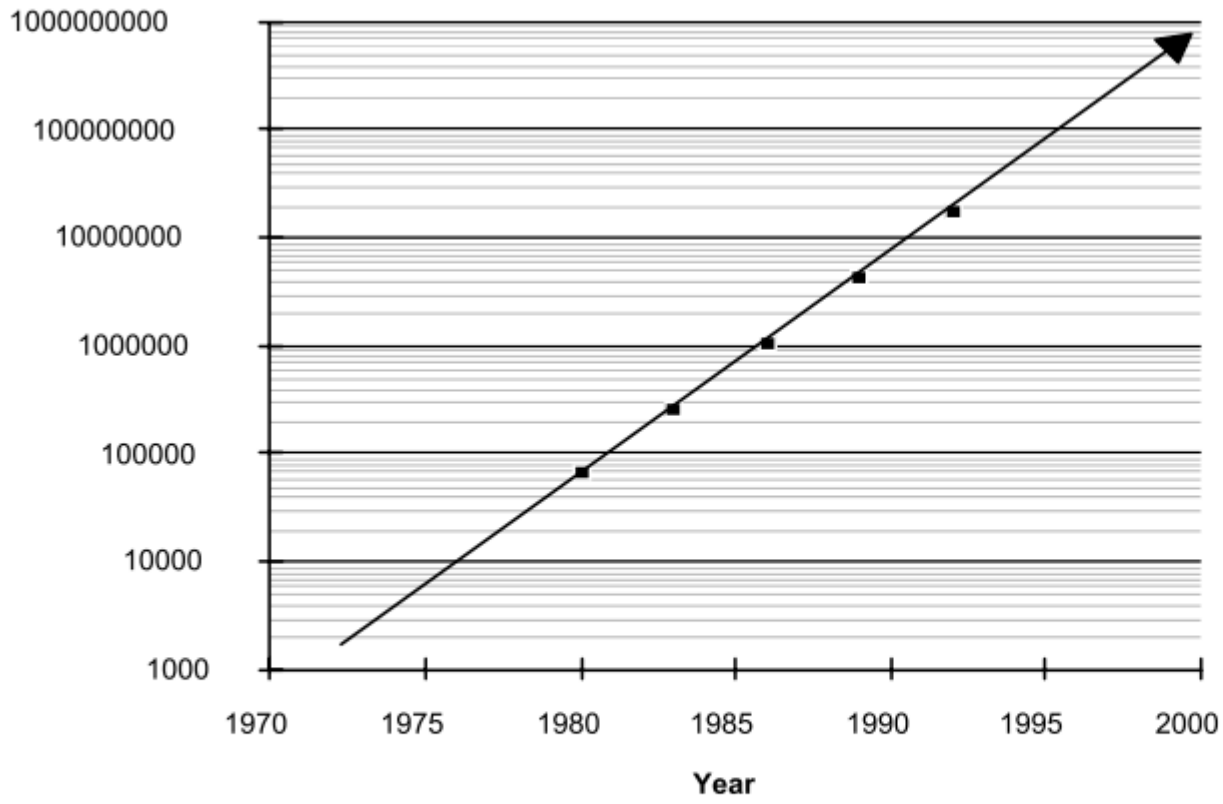
- Also called architecture
- A very important *abstraction*
  - interface between hardware and low-level software
  - Includes *instructions, registers, memory access, I/O and so on*
  - advantage: *different implementations* of the same architecture
  - disadvantage: sometimes prevents using new innovations
- Modern instruction set architectures:
  - IA-32, PowerPC, MIPS, SPARC, ARM, and others

Under the Covers
Anatomy: 5 components of any Computer




CLOCK DRIVER
CODE CACHE
INSTRUCTION FETCH
BRANCH PREDICTION LOGIC
CODE TLB
INSTRUCTION DECODE
BUS INTERFACE LOGIC
COMPLEX INSTRUCTION SUPPORT
DATA TLB
SUPERSCALER INTEGER EXECUTION UNITS
DATA CACHE
PIPELINED FLOATING POINT
MP LOGIC

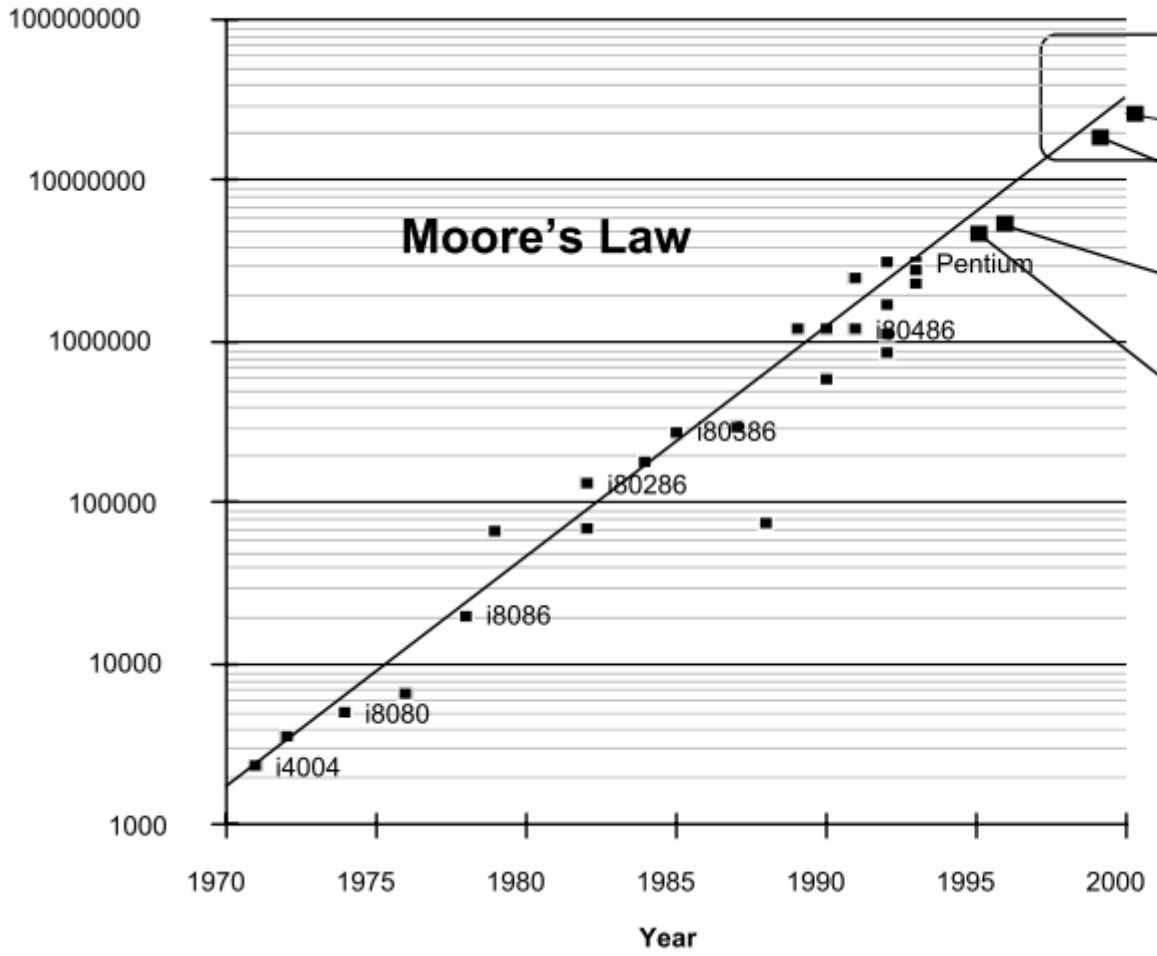
Technology Trends: Memory Capacity (Single-Chip DRAM)



year	size (Mbit)
1980	0.0625
1983	0.25
1986	1
1989	4
1992	16
1996	64
1998	128
2000	256
2002	512

- Now 1.4X/yr, or 2X every 2 years.
- 8000X since 1980!

Technology Trends: Microprocessor Complexity



Itanium 2: 410 Million

Athlon (K7): 22 Million

Alpha 21264: 15 million

Pentium Pro: 5.5 million

PowerPC 620: 6.9 million

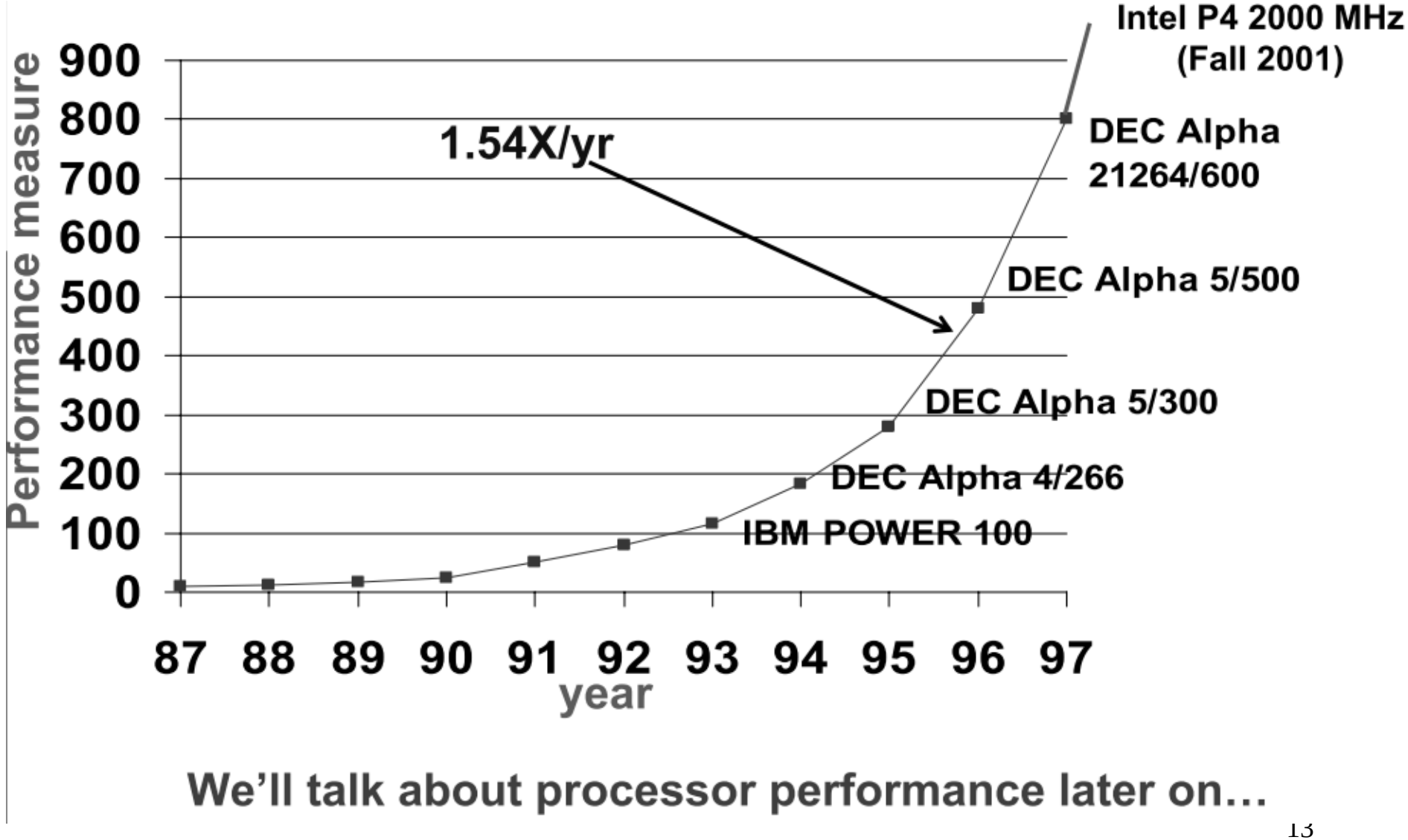
Alpha 21164: 9.3 million

Sparc Ultra: 5.2 million

2X transistors/Chip Every 1.5 years

Called "Moore's Law"

Technology Trends: Processor Performance



We'll talk about processor performance later on…

Computer Technology - Dramatic Change!

- Memory
  - DRAM capacity: 2x / 2 years (since ‘96);

    64x size improvement in last decade.
- Processor
  - Speed 2x / 1.5 years (since ‘85);

    100X performance in last decade.
- Disk
  - Capacity: 2x / 1 year (since ‘97)

    250X size in last decade.

Computer Technology - Dramatic Change!

- State-of-the-art PC when you graduate: (at least…)
  - 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})

The meaning of technology drive

- Forecast the expected design performance within the next few years
- It change the way that you design your computer, and software
  - Multi-processor, VLIW, parallel processor, efficient access via caches
  - Size, speed, probability
- Other technology may change the way of the computer/processor design
  - Quantum computer, DNA computer, bio-computer

Summary (What you should remember after 5 years)

- 5 classic components of all computers
  Control Datapath Memory Input Output
  processor
- Two key technologies for modern processors
  - Compilers
  - Silicon
    - Expected rates of technological rate
    - 2X every 2.0 years in memory size;
      every 1.5 years in processor speed;
      every 1.0 year in disk capacity;
    - Moore's Law enables processor
      (2X transistors/chip ~1.5 yrs)
  - Technology change the way you design computer and software
- Two key ideas for
  - Exploiting parallelism via pipelining
  - Exploiting locality of access via caches

References

- http://www-inst.eecs.berkeley.edu/~cs152