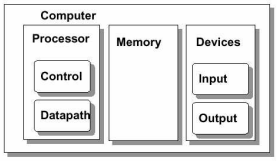
August 26

- TA: Angela Van Osdol in 036
- Questions?

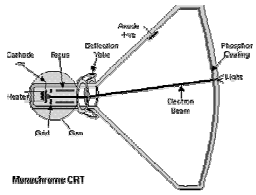
What is a computer?

- Tape drives?
- Big box with lots of lights?
- Display with huge letters?
- Little box with no lights?
- Lump in the cable?

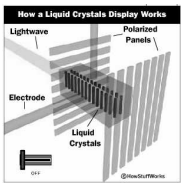
5 Classic Computer Components

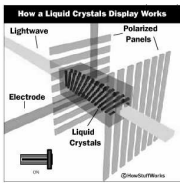


Display



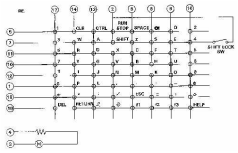
LCD



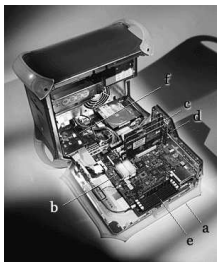


Mouse

Keyboard



Inside the case

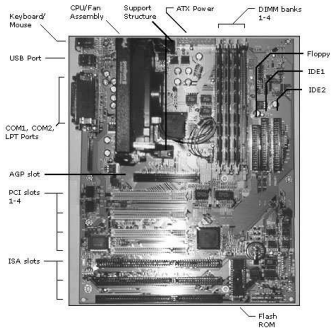


b. Processor

c. PCI slots

e. Memory slots

Motherboard

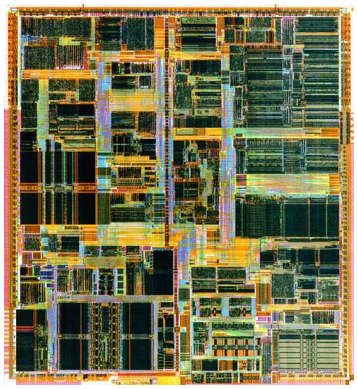


Memory

- RAM → Random Access Memory
- DRAM → Dynamic Random Access Memory
- SRAM → Static RAM
- ROM → Read-only Memory
- Volatile / Non-Volatile → needs power or not
- Magnetic → stores bits as magnetized regions

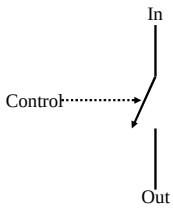
Processor

Pentium III Xeon



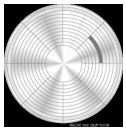
You only need switches and wires!

- Relays
- Vacuum tubes
- Transistors
- Integrated Circuits
- VLSI
- Nanotubes?
- Quantum Effect Devices?



Disk Drive

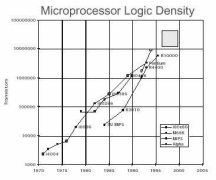


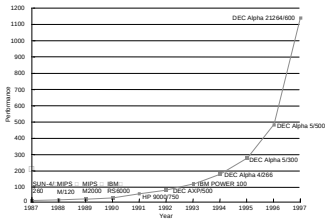
Improving Technology

DRAM chip capacity

DRAM	
Year	Size
1980	64 Kb
1983	256 Kb
1986	1 Mb
1989	4 Mb
1992	16 Mb
1996	64 Mb
1999	256 Mb
2002	1 Gb



Performance Increase



Abstractions

- What the user wanted.
- What the programmer designed.
- What the programmer thought about.
- What the language allowed.
- Assembly language.
- Binary.
- Function blocks.
- Gates
- Devices
- Physics

Abstraction: C to ASM

```
Swap(int v[], int k) {
  int temp;
  temp = v[k]; v[k] = v[k+1]; v[k+1] = temp;
}
```

C compiler

Assembly

```
Swap:
        muli $2, $5, 4
        add $2, $4, $2
        lw $15, 0($2)
        lw $16, 4($2)
        sw $16, 0($2)
        sw $15, 4($2)
        jr $31
```

Abstraction: ASM to Binary

Assembly

```
Swap:
        muli $2, $5, 4
        add $2, $4, $2
        lw $15, 0($2)
        lw $16, 4($2)
        sw $16, 0($2)
        sw $15, 4($2)
        jr $31
```

Assembler

```
00000000101000010000000000011000
00000000100011100001100000100001
10001100011000100000000000000000
10001100111100100000000000000100
10101100111100100000000000000000
10101100011000100000000000000100
00000011111000000000000000001000
```

Binary

Instruction Set Architecture

... 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

- interface between hardware and low-level software
- standardizes instructions, machine language bit patterns, etc.
- advantage: *different implementations of the same architecture*
- disadvantage: *sometimes prevents using new innovations*

Modern instruction set architectures:
- 80x86/Pentium/K6, PowerPC, DEC Alpha, MIPS, SPARC, HP

CISC vs. RISC

- ISA's originally for humans to use
- Small memory size was critical thus complex instructions
- High-level-language architectures (B5000)
- RISC says do a few things well; only supply what the compiler will use; rely on compiler to get it right.

Why look at MIPS?

- Why not one that *matters* like Intel?

Complexity…
Ugliness…
Horror…
Reality…

The Really Big Ideas

- Just **bits** for data and program
- Program is a sequence of instruction words
- Data-type determined by instruction
- Large linear "array" of memory
- Small number of "variables" (registers)

Just Bits

- Program and data have the same representation
- Programs can manipulate programs
- Programs can manipulate themselves!
- Bits not the only way (Lisp)

Data Types

- char byte short int pointer quad float double
- Instruction determines type of operands
  - Add (int), Add.s (float), Add.d (double)
- Free to reinterpret at will
- How big is a char?
- What's a pointer?

Memory

- Large (usually) linear array
- Only **read** with load instructions
  - lw $t5, 100($a3) ($t5 = mem[100+$a3])
- Only **modified** with store instructions
  - sw $s0, 24($t3) (mem[24+$t3] = $s0)
- CISC machines have lots of ways to read and write memory

Memory

- Address is always in bytes
- Words on 4 byte boundary (how many 0's?)
- Short only on 2 byte boundary
- Doubles only on 8 byte boundary
- CISC allowed them anywhere

  Why?

It's an ABSTRACTION!

GP Registers

- Variables for our programs
- The ONLY operands for most instructions
- A very small number (32 in MIPS)

  Why?
- All 32 bits
- What about new 64 bit ISA's?

Where we are headed

- Overview of C
- Performance issues (Chapter 2) *vocabulary and motivation*
- A specific instruction set architecture (Chapter 3) **Why MIPS? Why not Intel?**
- Arithmetic and how to build an ALU (Chapter 4)
- Pipelining to improve performance (Chapter 6) *briefly*
  Memory: caches and virtual memory (Chapter 7)
- **Key to a good grade: reading the book!**