Announcements

Project 2B turn-in Wednesday 11:00PM
Midterm 2 on Friday
  Only on material since last midterm

Computer Basics

How exactly does a computer work?

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Integrated Circuits

Integrated circuits (ICs) are the power source of the information revolution
  • When computers were made of discrete parts, wires of every transistor (3), capacitor (2), resistor (2), etc. had to be hand-connected
  • Labor intensive, expensive, error prone, unreliable, cumbersome, … even with robots!
  • Integrated circuits solved that by 2 ideas
    Integration -- circuits built as a unit from like parts
    Photolithography -- printing process to make chips

Intel Pentium Processor

Photolithography

Consider process for depositing wires

Remove Resist

The cost of the circuit is not related to complexity
Silicon, a semiconductor -- sometimes it conducts and sometimes it doesn’t

- It's possible to control when semiconductors do and don't conduct

**Ex. Use control to test (Mars AND rover)**
- Make semiconductor conduct if “Mars” is found
- Make semiconductor conduct if “rover” is found
- Send “yes” signal on wire
- Detect presence/absence of “yes”

**Field Effect**
- Charged objects are familiar -- use a nylon comb on a dry day
  - A charged field can control whether a semiconductor conducts or not
  - The charge of the control wire (gate) is key
  - Neutral gate, channel doesn't conduct
  - Charged gate, channel conducts

**MIPS R10000 Processor**
- Notice that wires cross over other wires...

**MOS Transistors**
- The field effect idea is implemented in metal-oxide-semiconductor transistors

**Operation**
- The two cases: the gate is neutral or the gate is charged

Notice key points of integrated circuits:
- Constructed as a unit of compatible parts
- Fabricated in layers by photolithography
Computers...

Deteministically execute instructions to process information

“Deterministically” means that when a computer chooses the next instruction to perform it is required by its construction to execute a specific instruction based only on the program and input it is given.

Computers have no free will and they are not cruel.

Fetch/Execute Cycle

Computer = instruction execution engine

- The fetch/execute cycle is the process that executes instructions
  - Instruction Fetch (IF)
  - Instruction Decode (ID)
  - Data Fetch (DF)
  - Instruction Execution (EX)
  - Result Return (RR)

Anatomy of a Computer

Memory...

Programs and their data must be in the memory while they are running.

Memory locations

- memory addresses
- memory contents
- byte = 8 bits
- Groups of four bytes are a word

Control

The Fetch/Execute cycle is hardwired into the computer’s control, i.e. it is the actual “engine”

The instructions executed have the form

ADD 20, 10, 16

Indirect Data Reference

Instructions tell where the data is, not what the data is... contents change

One instruction has many effects

ADD 20, 10, 16
**ALU**

The Arithmetic/Logic Unit does the actual computation

Each type of data has its own separate instructions:
- `ADDB`: add bytes
- `ADDBU`: add bytes unsigned
- `ADDH`: add half words
- `ADDHU`: add halves unsigned
- `ADD`: add words
- `ADDU`: add words unsigned
- `ADDS`: add short decimal numbers
- `ADDD`: add long decimal numbers

Most computers have only about 100-150 instructions hard wired.

**Input/Output**

Input units bring data to memory from outside world; output units send data to outside world from memory.

- Most peripheral devices are “dumb” meaning that the processor assists in their operation.
- Disks are memory devices because they can output information and input it back again.

**The PC’s PC**

The program counter (PC) tells where the next instruction comes from.

- Instructions are a word long, so add 4 to the PC to find the next instruction.

Program Counter: 112

110 111 112 113 114 115 116 117 118 119 120 121 ...

**Clocks Run The Engine**

The rate a computer “spins around” the Fetch/Execute cycle is controlled by its clock.

- Current clocks run 2-3 GHz.
- In principle, the computer should do one instruction per cycle, but often it fails to.
- Modern processors try to do more than one instruction per cycle, and often succeed.

Clock rate is not a good indicator of speed.

**Summary**

Semiconductors make Info Revolution

- Semiconductors properties...

  Fields controls when semiconductor conducts

  On/off of conductors allows us to compute

Fetch/execute cycle runs instructions:

- 5 steps to interpret machine instructions
- Programs must be in the memory
- Data is moved in and out of memory

Instructions, data are represented in binary.