



Announcements

Project 1b is due Monday

Tests are graded, expect them back shortly. (I was pleased with the results.)

1



Computer Basics

How exactly does a computer work?

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2



Integrated Circuits

Integrated circuits (ICs) are the power source of the information revolution

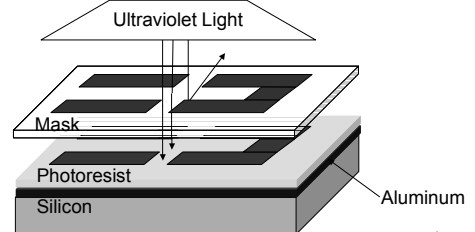
- When computers were made of discrete parts, wires of every transistor (3), capacitor (2), resistor (2), etc. had to be hand-connected
- Labor intensive, expensive, error prone, unreliable, cumbersome, ...
- Integrated circuits solved that by 2 ideas
 - Integration -- circuits built as a unit from like parts
 - Photolithography -- printing process to make chips

3



Photolithography

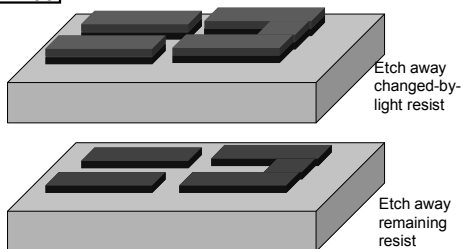
Consider process for depositing wires



4



Remove Resist



The cost of the circuit is not related to complexity

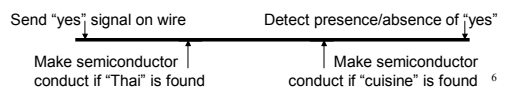


Semiconductors

Silicon, a semiconductor -- sometimes conducts and sometimes does not

- When semiconductors do and don't conduct can be controlled
- The degree to which semiconductors conduct can be enhanced

Ex.: Use control to test **Thai AND cuisine**




6



Field Effect

Charged objects are familiar -- use a nylon comb on a dry day

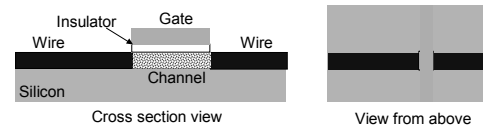
- A charged field can control whether a semiconductor conducts or not
- The plan  A transistor has 3 wires
- The control wire's charge is the key
- Neutral control wire, wire does not conduct
- Charged control wire, implies wires conduct

7



MOS TRansistors

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

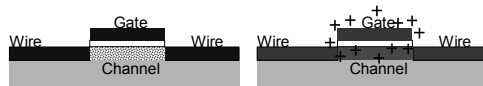


8



Operation

The two cases are, 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

9



Computers ...

Deterministically 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

10



Fetch/Execute Cycle

Computer = instruction execution engine

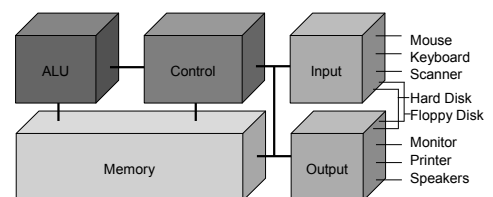
- The fetch/execute cycle is the process that executes instructions

Instruction Fetch (IF)
Instruction Decode (ID)
Data Fetch (DF)
Instruction Execution (EX)
Result Return (RR)

11




Anatomy of a Computer



The Hard Disk is the α -device

12



Memory ...

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

Memory locations

0	1	2	3	4	5	6	7	8	9	10	11	...
S o D a w g s t r i n g												

memory addresses


memory contents

byte=8 bits

0	1	0	0	0	0	0	0
---	---	---	---	---	---	---	---

Groups of four bytes are a word

13



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 10, 16, 20

10	11	12	13	14	15	16	17	18	19	20	21	...
6												

12

18

Put in memory location 20 the contents of memory location 10 + contents of memory location 16



Indirect Data Reference

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

One instruction has many effects
ADD 10, 16, 20


10	11	12	13	14	15	16	17	18	19	20	21	...
8												

10	11	12	13	14	15	16	17	18	19	20	21	...
80												

-35

5

15



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

16




Input/Output

Input units move data from memory to outside world; output units bring data from outside world into 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

17



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	121
ADD 10, 16, 20												
AND 4, 4, 16, 20												
OR												

18



Clocks Run The Engine

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

- 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

19