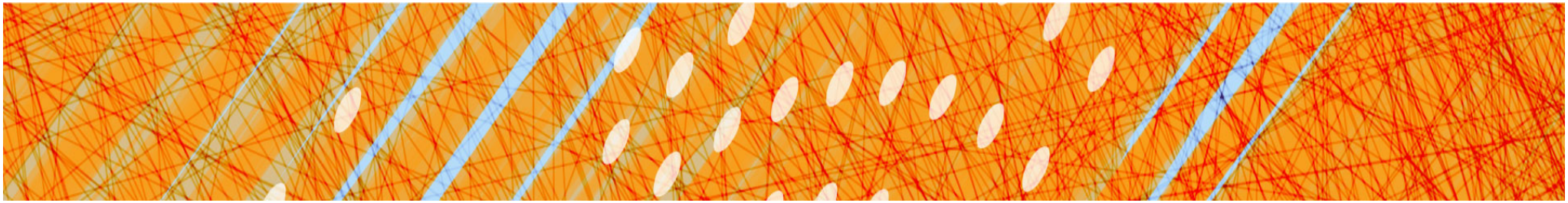


Introduction

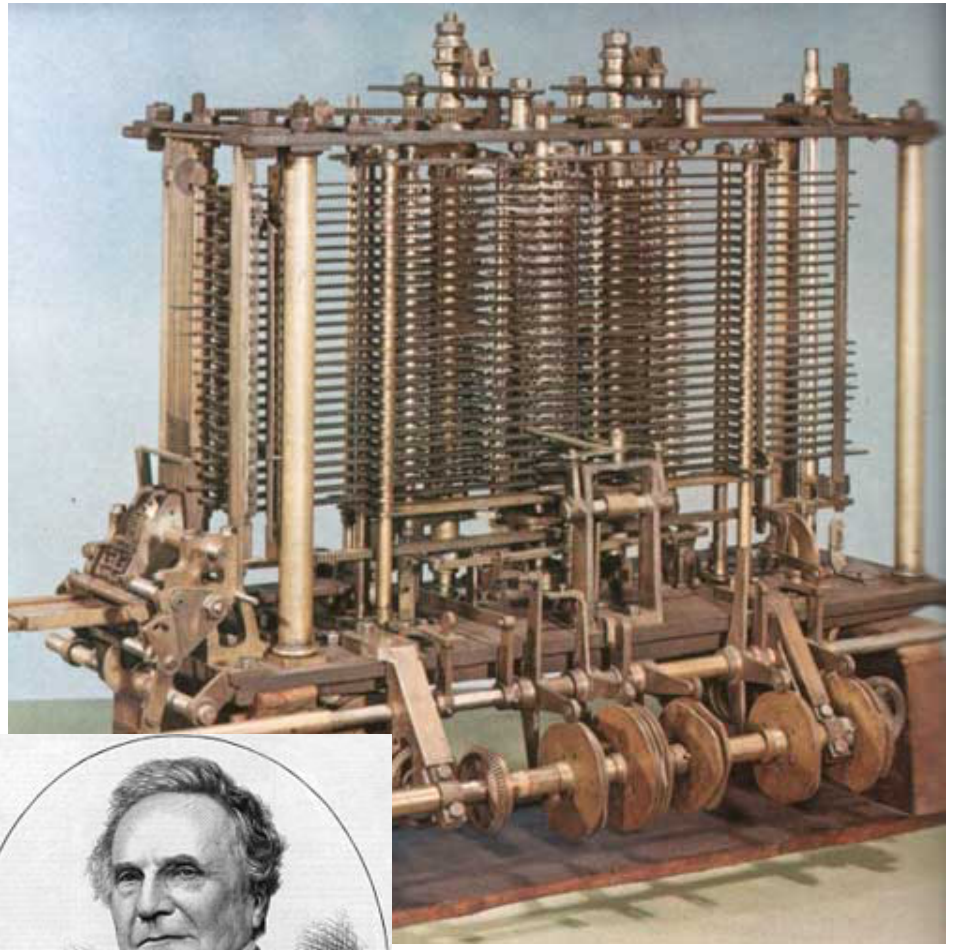
CS 3410: Computer System Organization and Programming

Cornell CIS
COMPUTING AND INFORMATION SCIENCE

[K. Bala, A. Bracy, E. Sirer, and H. Weatherspoon]

The Analytical Engine

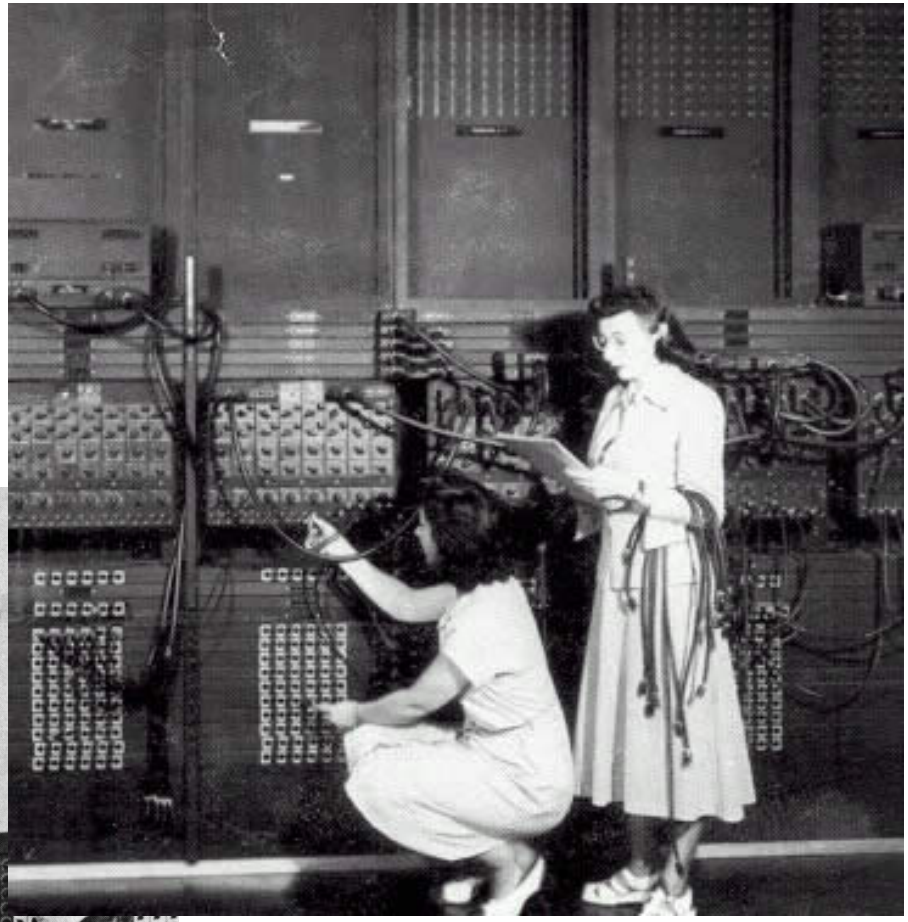
- Designed by Charles Babbage from 1834 – 1871
- Considered to be the first digital computer
- Built from mechanical gears, where each gear represented a discrete value (0-9)
- Babbage died before it was finished

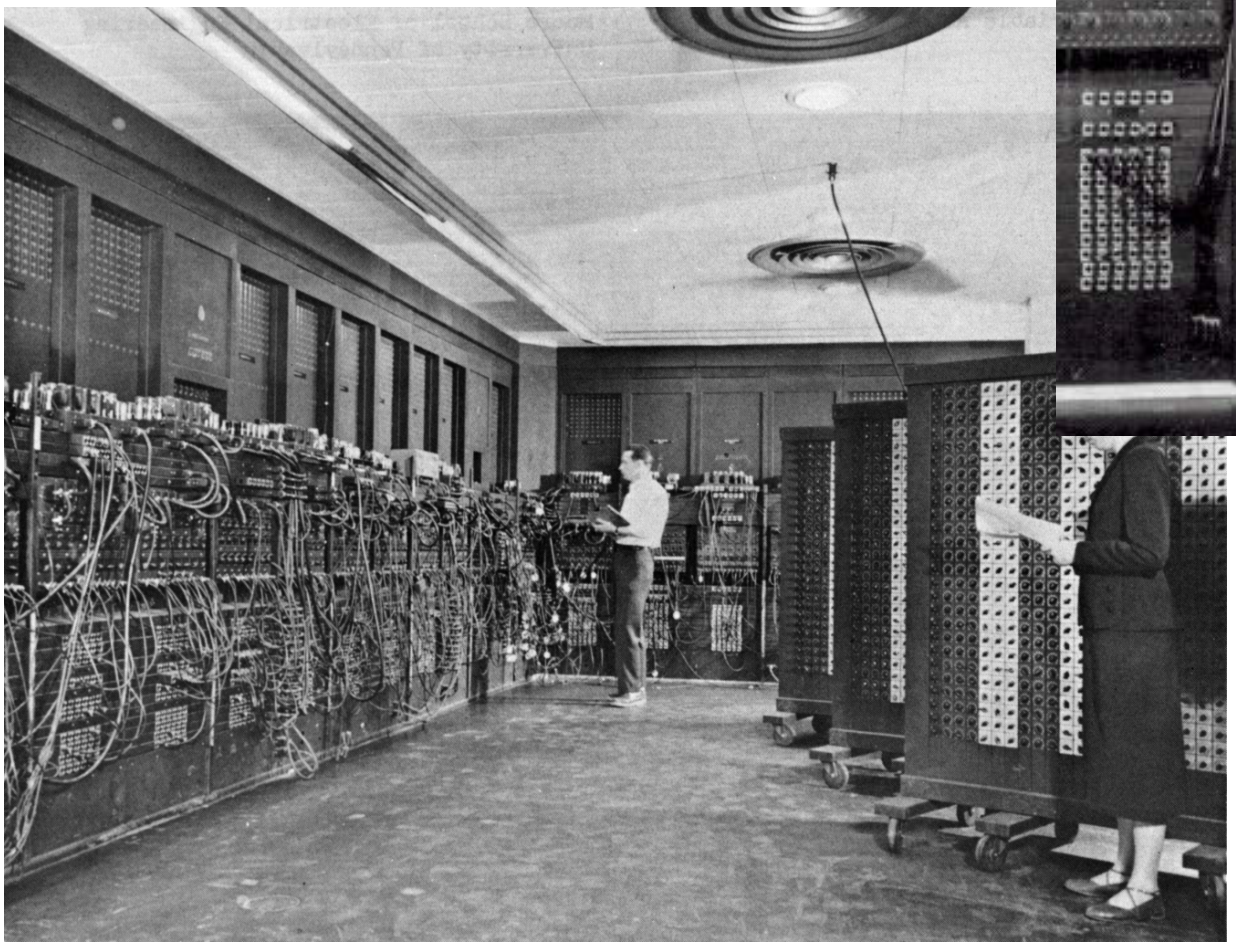


http://history-computer.com
http://wikimedia.com

ENIAC

Electronic Numerical Integrator And Computer





1946

John Mauchly

J. Presper Eckert

Who are you?

"Sometimes it is the people that no one imagines anything of who do the things that no one can imagine." – Alan Turing

- Turing Award Winners?
- Eckert Mauchly Award Winners?

Course Objective

- Understand the HW / SW interface software
  - How a processor works
  - How a computer is organized
- Establish a foundation for building applications
  - How to write a good program
    - Good = correct, fast, and secure
  - How to understand where the world is going
- Understand technology (past, present, future)

What is this?

```
#include <stdio.h>

int main() {
   printf("Hello world!\n");
   return 0;
}
```

How does it work?

I'm glad you asked…

15 weeks later and you'll know!

"I know Kung Fu."

Compilers & Assemblers

C

```
int x = 10;
x = 2 * x + 15;
```

compiler

r0 = 0

MIPS assembly language

```
addi r5, r0, 10
muli r5, r5, 2
addi r5, r5, 15
```

r5 = r0 + 10

r5 = r5 * 2

r5 = r5 + 15

assembler

MIPS machine language

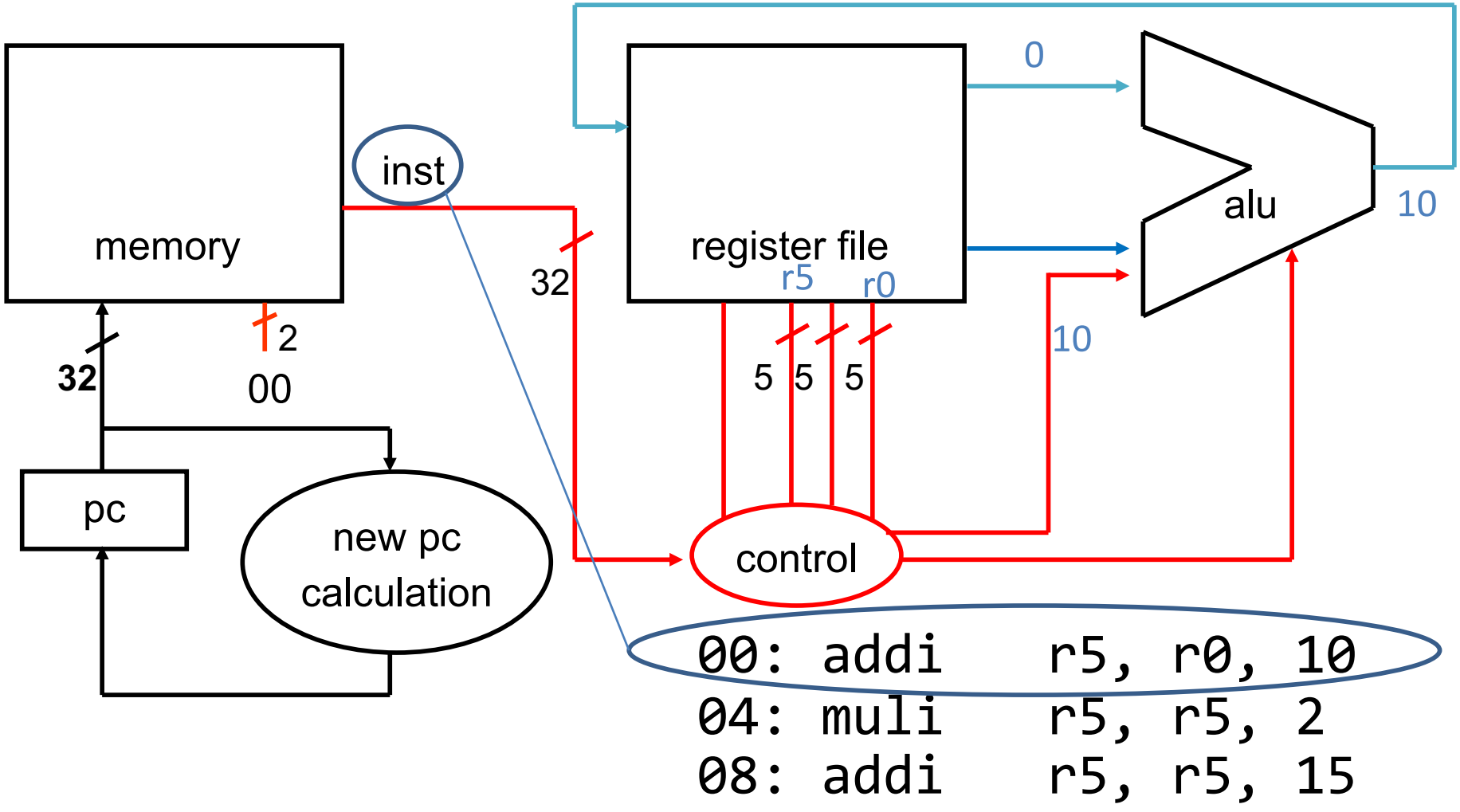
op = addi r0 r5 10

```
001000 00000 00101 0000000000001010
00000000000010100101000001000000
001000 00101 00101 0000000000001111
```

op = addi r5 r5 15

Everything is a number!

How to Design a Simple Processor

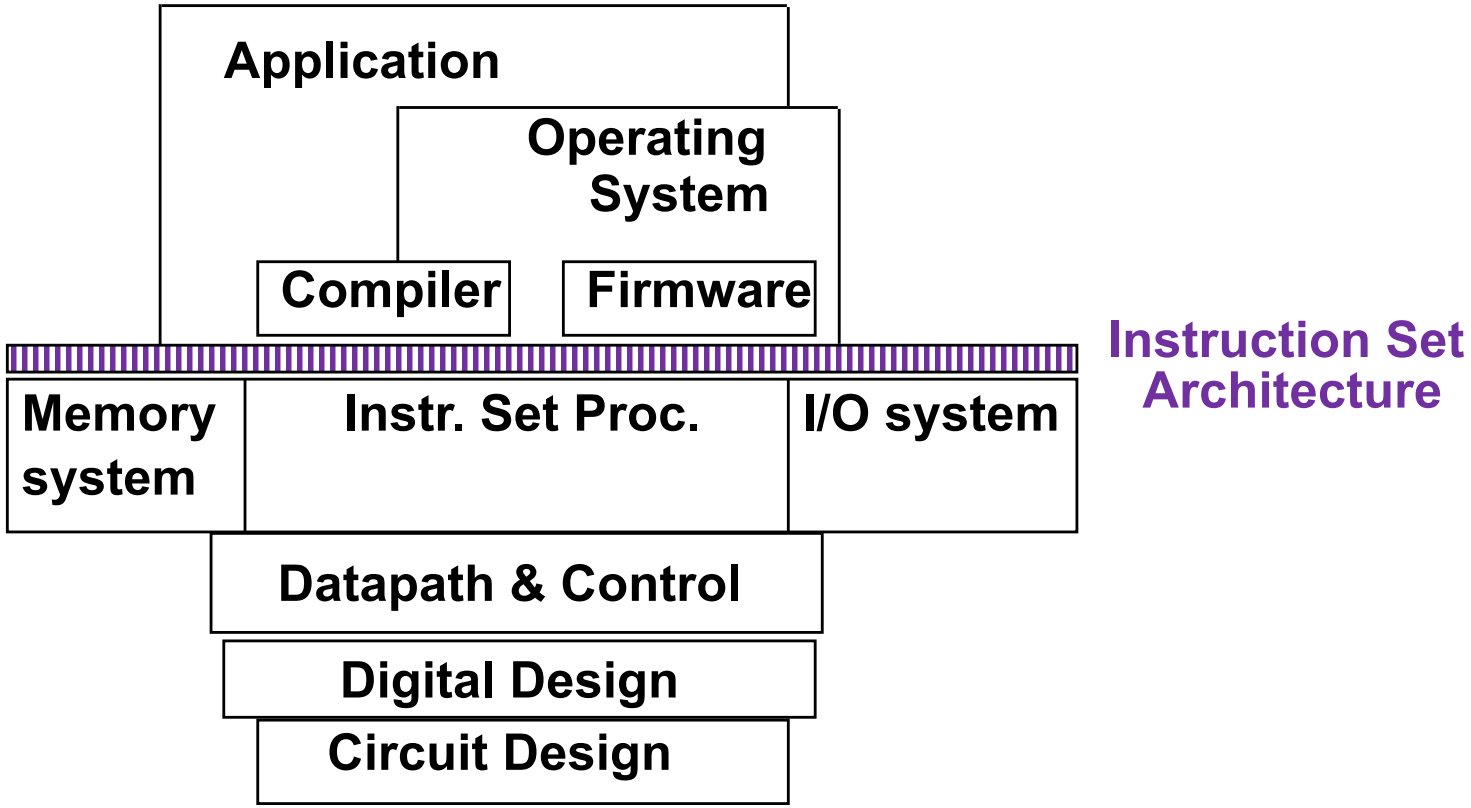


Instruction Set Architecture (ISA)

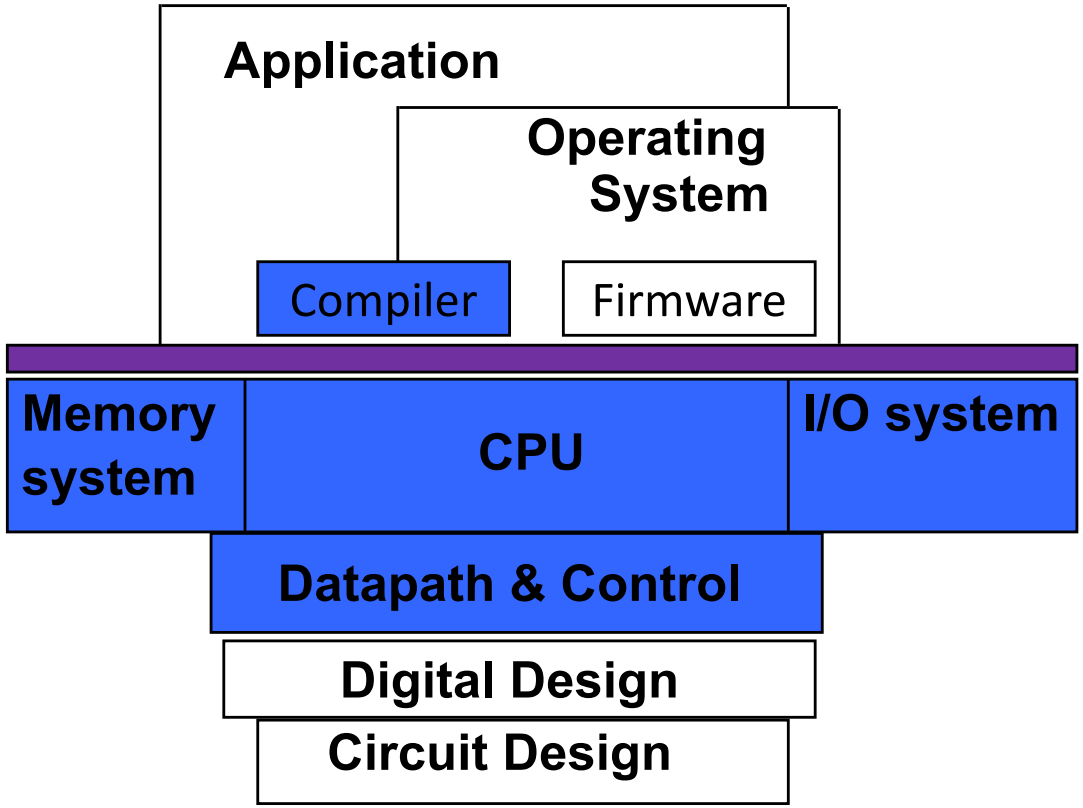
- abstract interface between hardware and the lowest level software

- user portion of the instruction set plus the operating system interfaces used by application programmers

Overview

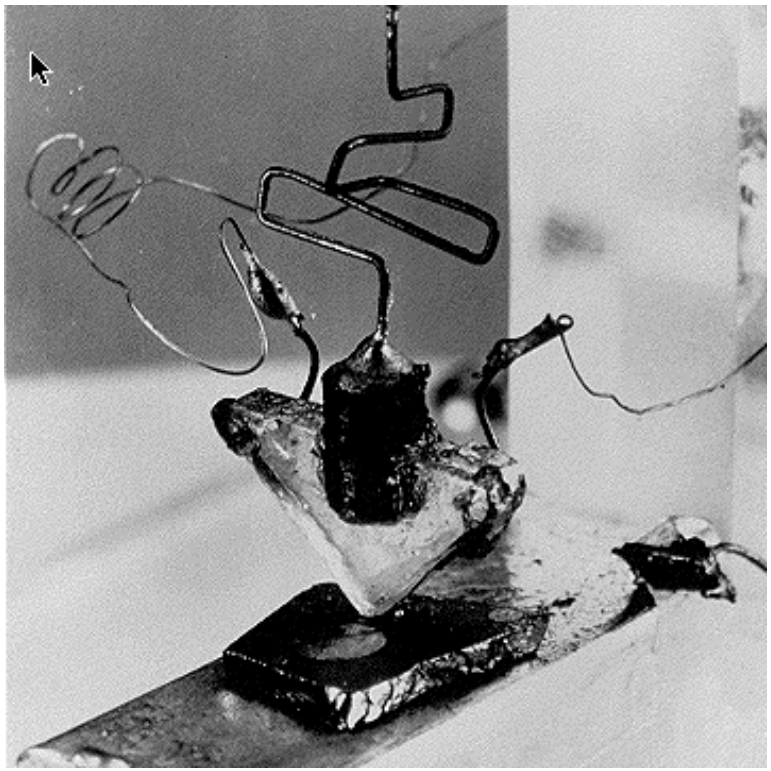

Application
Operating System
Compiler
Firmware
Instruction Set Architecture
Memory system
Instr. Set Proc.
I/O system
Datapath & Control
Digital Design
Circuit Design

Covered in this course



Where did it begin?

- Electrical Switch
  - On/Off
  - Binary
- Transistor

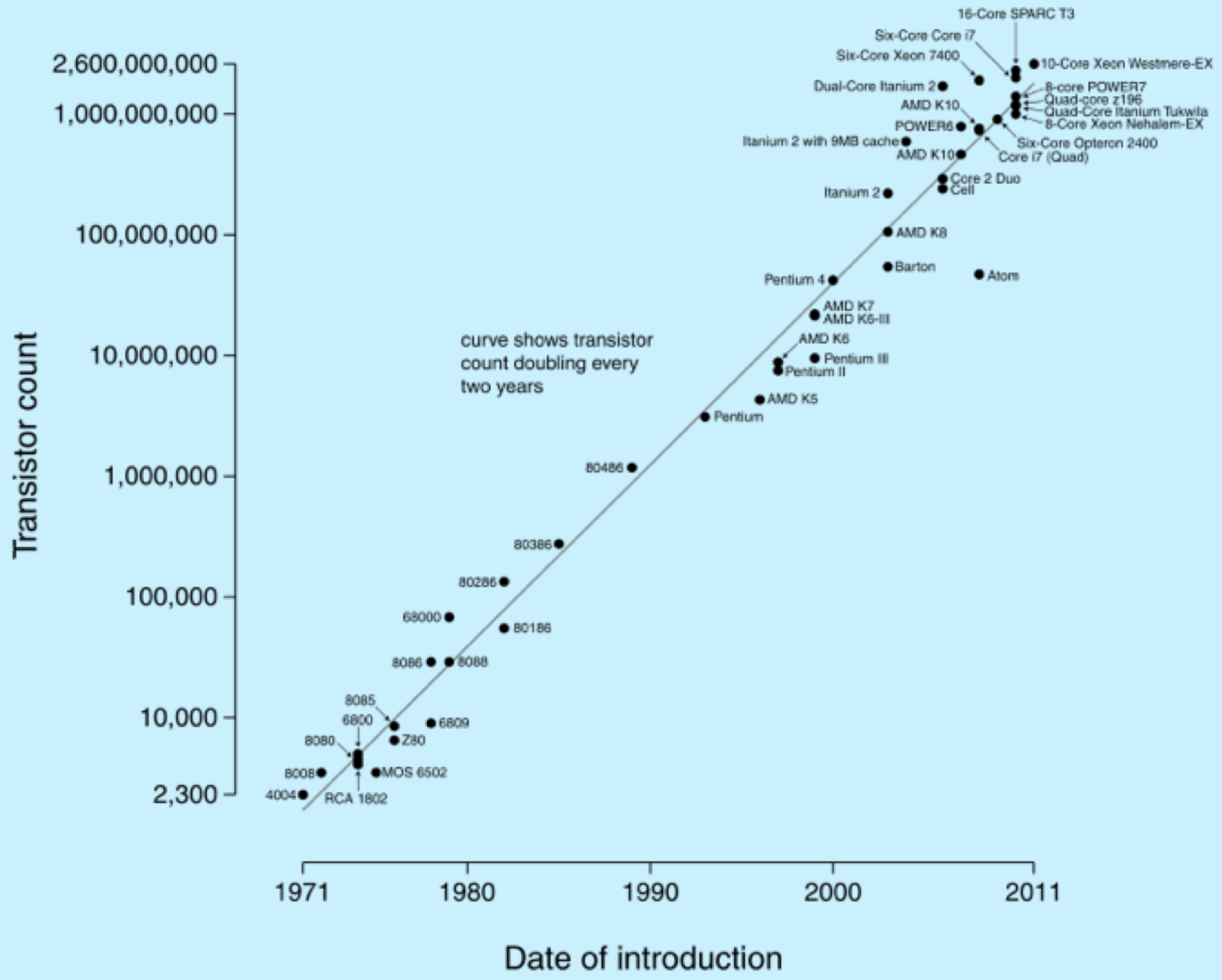


The first transistor on a workbench at AT&T Bell Labs in 1947

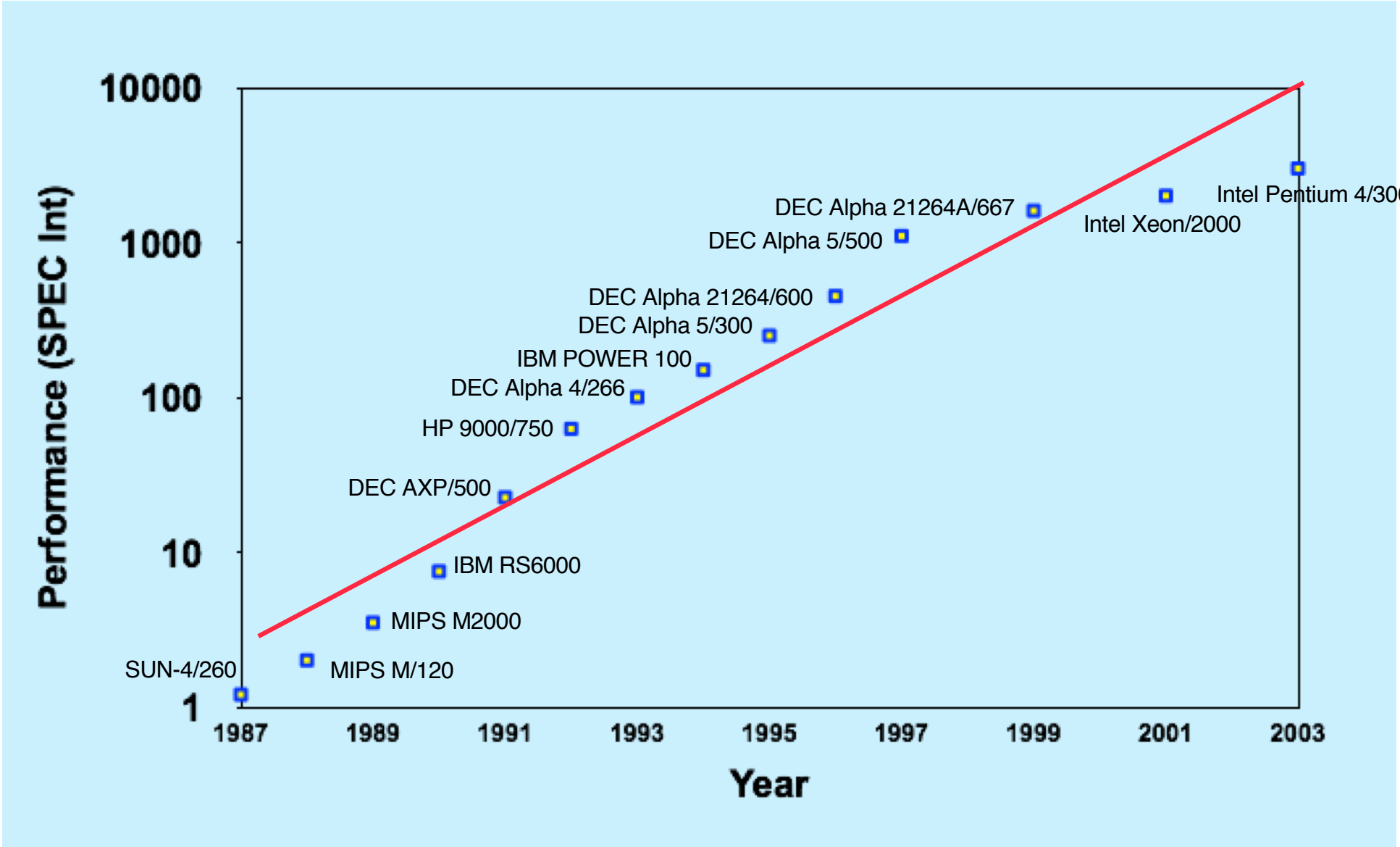
Moore's Law

- 1965
  - # of transistors integrated on a die doubles every 18-24 months (*i.e.,* grows exponentially with time)

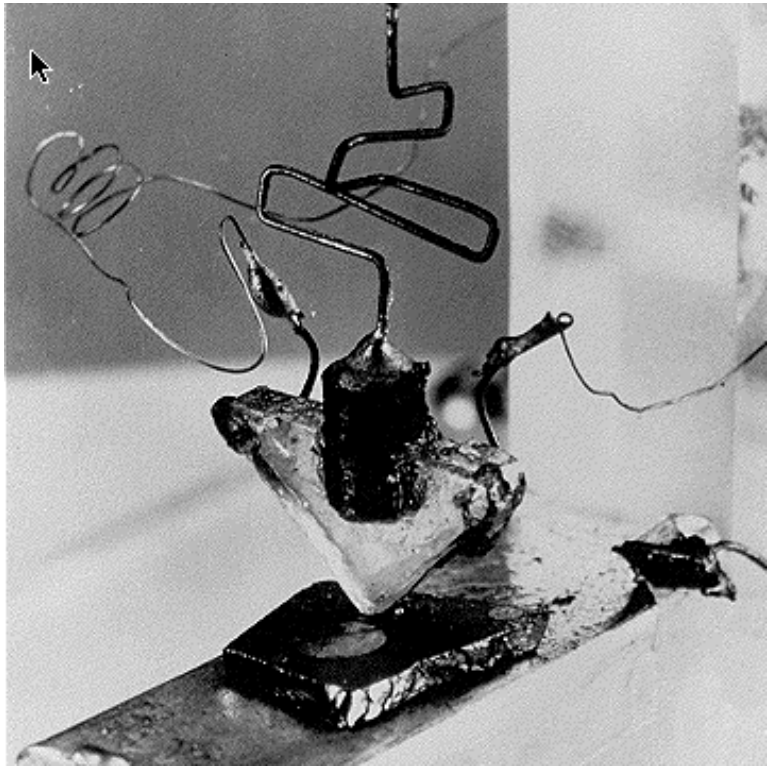
- Amazingly visionary
  - 2300 transistors, 1 MHz clock (Intel 4004) - 1971
  - 16 Million transistors (Ultra Sparc III)
  - 42 Million transistors, 2 GHz clock (Intel Xeon) – 2001
  - 55 Million transistors, 3 GHz, 130nm technology, 250mm^2 die (Intel Pentium 4) – 2004
  - 290+ Million transistors, 3 GHz (Intel Core 2 Duo) – 2007
  - 721 Million transistors, 2 GHz (Nehalem) - 2009
  - 1.4 Billion transistors, 3.4 GHz Intel Haswell (Quad core) – 2013

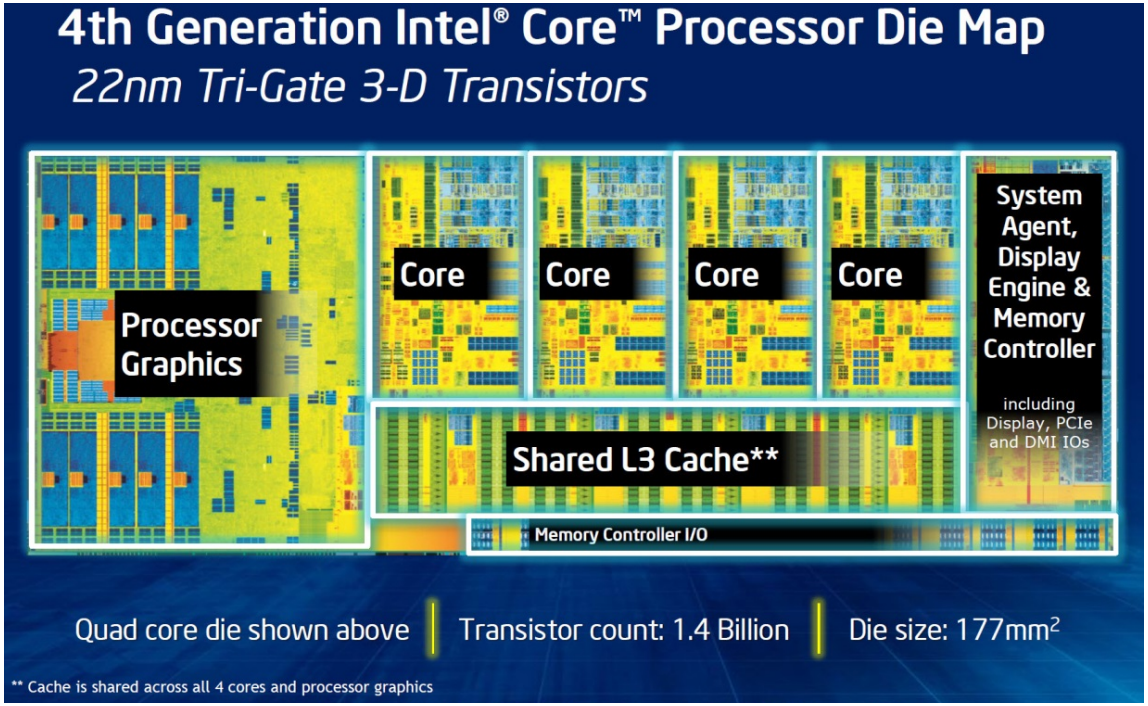

Microprocessor Transistor Counts 1971-2011 & Moore's Law
Transistor count
2,600,000,000
1,000,000,000
100,000,000
10,000,000
1,000,000
100,000
10,000
2,300
curve shows transistor count doubling every two years
16-Core SPARC T3
Six-Core Core i7
Six-Core Xeon 7400
10-Core Xeon Westmere-EX
Dual-Core Itanium 2
8-core POWER7
Quad-core z196
Quad-Core Itanium Tukwila
AMD K10
POWER6
8-Core Xeon Nehalem-EX
Itanium 2 with 9MB cache
Six-Core Opteron 2400
AMD K10
Core i7 (Quad)
Core 2 Duo
Cell
Itanium 2
AMD K8
Barton
Atom
Pentium 4
AMD K7
AMD K6-III
AMD K6
Pentium III
Pentium II
AMD K5
Pentium
80486
80386
80286
68000
80186
8086
8088
8085
6800
6809
8080
Z80
8008
MOS 6502
4004
RCA 1802
1971
1980
1990
2000
2011
Date of introduction

Processor Performance Increase



Then and Now



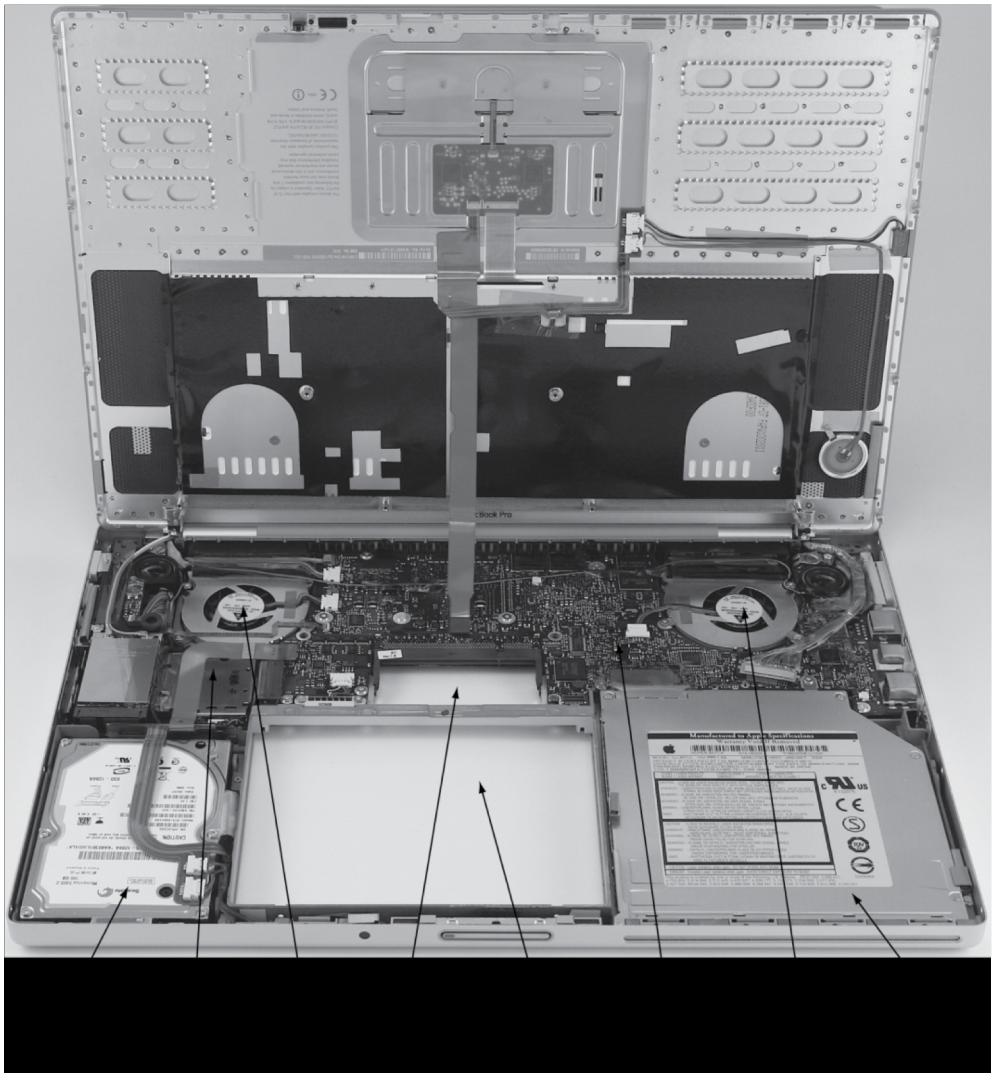


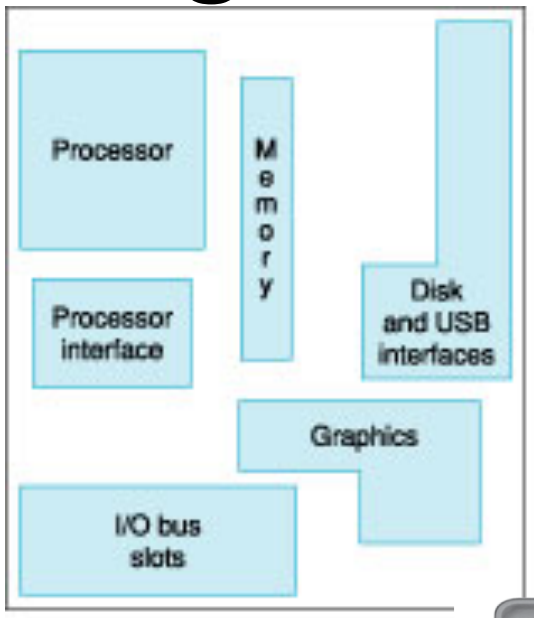
http://techguru3d.com/4th-gen-intel-haswell-processors-architecture-and-lineup/

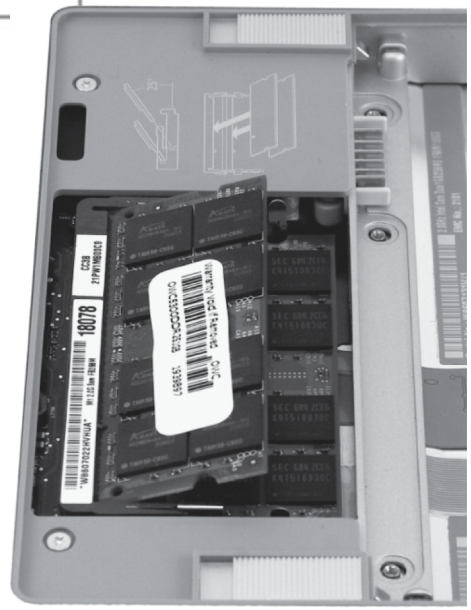
- The first transistor
  - One workbench at AT&T Bell Labs
  - 1947
  - Bardeen, Brattain, and Shockley
- Intel Haswell
  - 1.4 billion transistors
  - 177 square millimeters
  - Four processing cores

What are we doing with all these transistors?

Computer System Organization







Reflect

Why take this course?

Basic knowledge needed for *all* other areas of CS:

operating systems, compilers, ...

Levels are not independent

hardware design ↔ software design ↔ performance

Crossing boundaries is hard but important

device drivers

Good design techniques

abstraction, layering, pipelining, parallel vs. serial, ...

Understand where the world is going

The Mysteries of Computing will be revealed!