Introduction

CMSC 313: Assembly Language and Computer Organization

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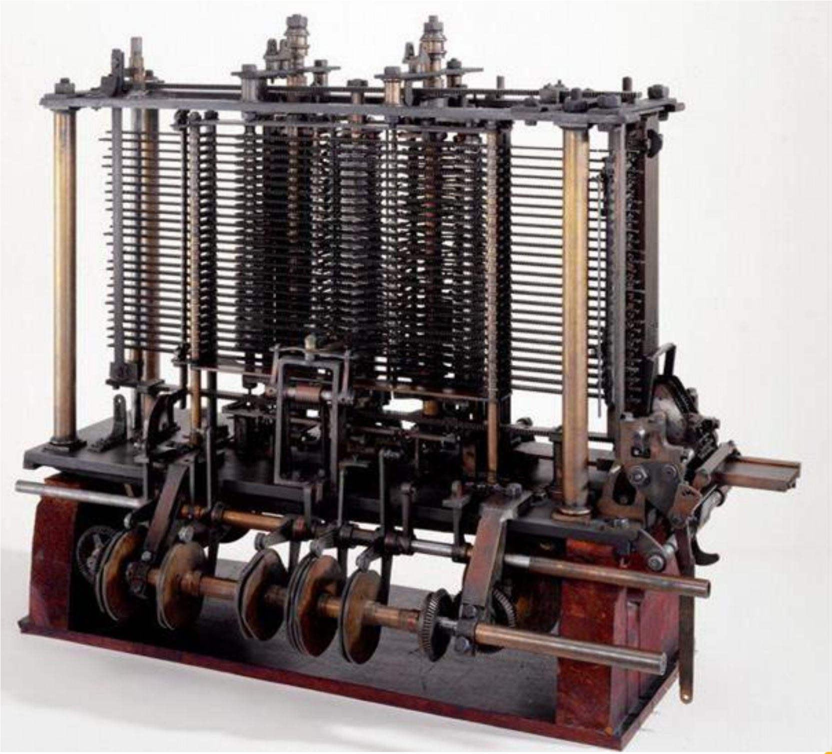
Programming the Loom

- 1801: Joseph Marie Jacquard invents a loom that uses punch cards to automate designs woven into fabric. Early computers continued this design by also using punch cards.

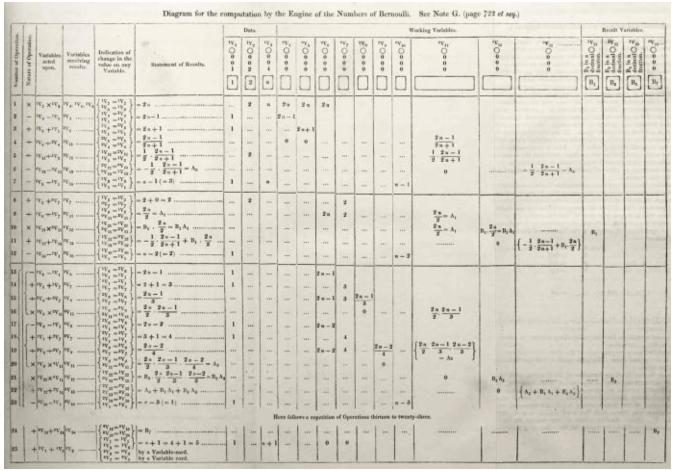
Analytical Engine

- 1821: Charles Babbage designs steam driven calculating machine that could produce polynomial coefficients - “Difference Engine”.
- 1837: “Analytical Engine” could perform any kind of calculation - had memory, an ALU, branching, & was theoretically turing-complete
- Lost funding before being completed



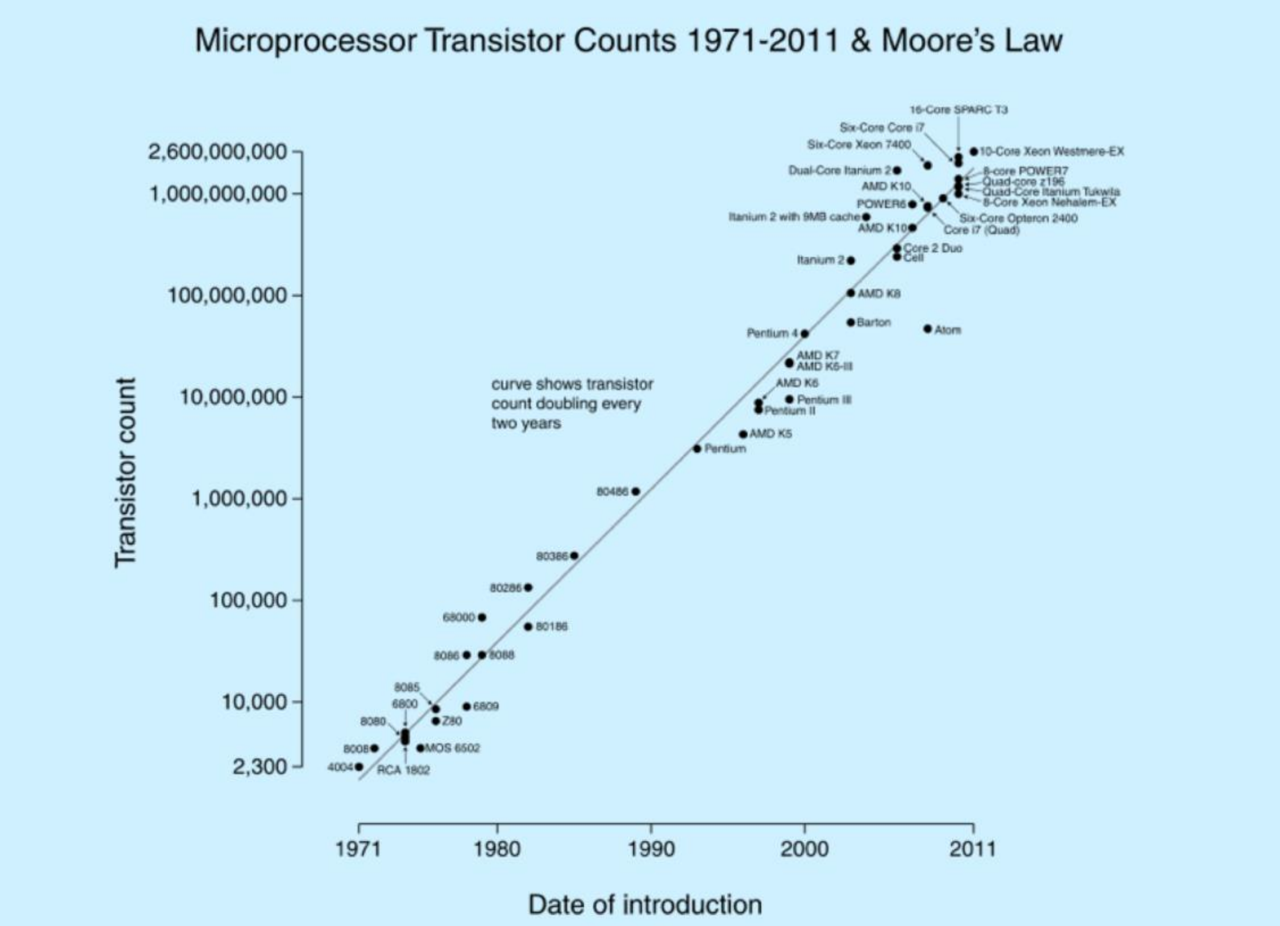
First Computer Program

- 1843: Ada wrote a step-by-step description for calculating Bernoulli Numbers using the “Analytical Engine”. Used memory for recursion.

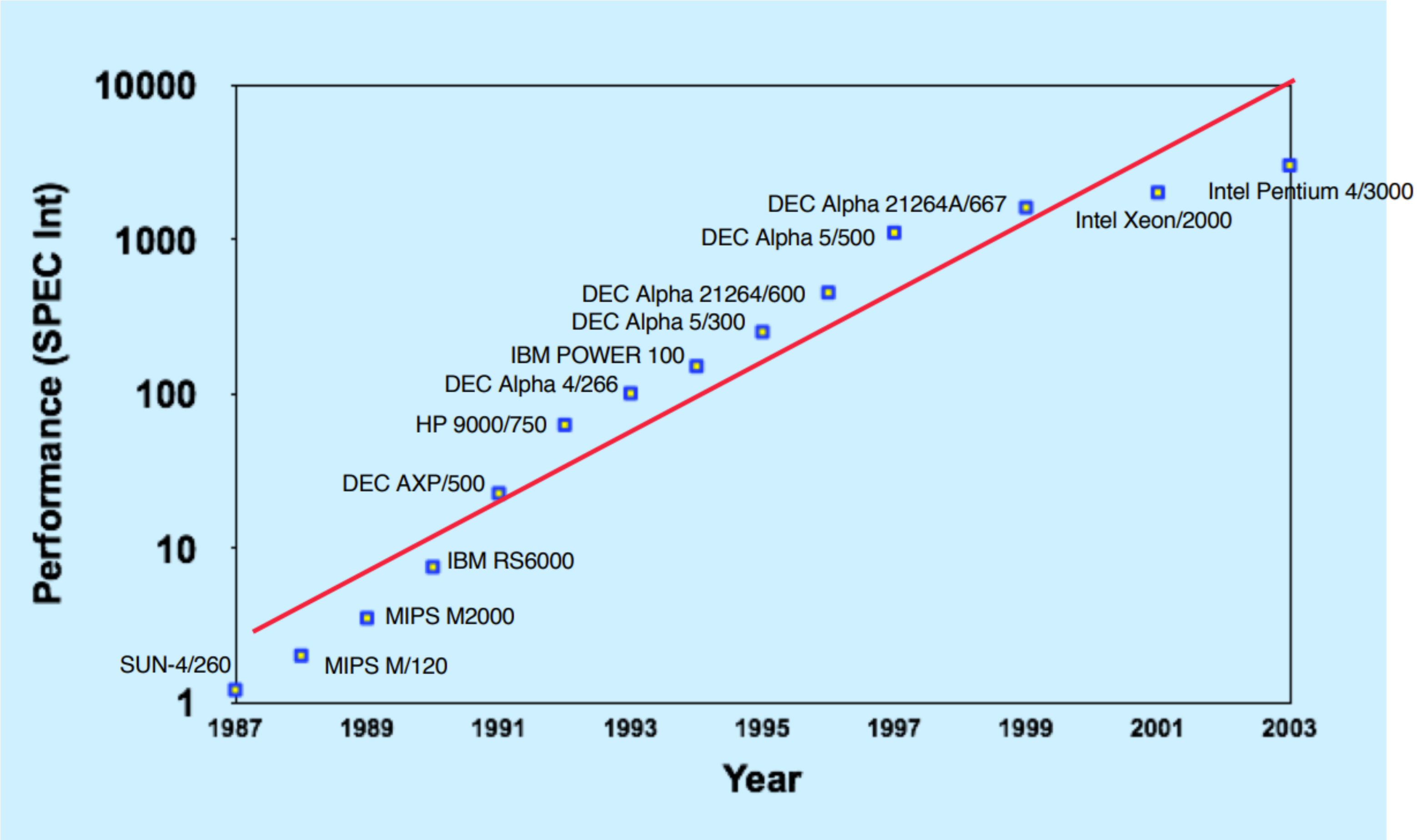


Moore’s law and Dennard scaling

- Moore’s Law: # of transistors integrated on a die doubles every 18-24 months (i.e., grows exponentially with time).
- Dennard Scaling: as transistors get smaller, their power density stays constant.
- Motivation to improve architecture (system level)

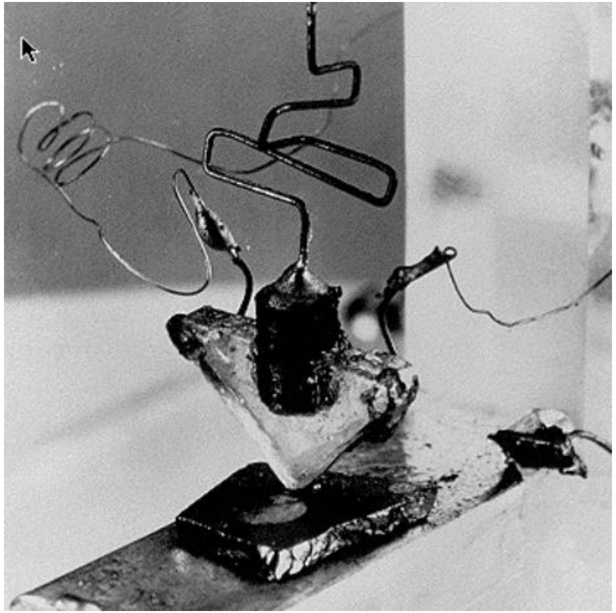


Microprocessor Transistor Counts 1971-2011 & Moore's Law
Transistor count
Date of introduction
2,600,000,000
1,000,000,000
100,000,000
10,000,000
1,000,000
100,000
10,000
2,300
1971
1980
1990
2000
2011
curve shows transistor count doubling every two years
16-Core SPARC T3
Six-Core Core i7
Six-Core Xeon 7400
10-Core Xeon Westmere-EX
Dual-Core Itanium 2
8-core POWER7
Quad-core z196
Quad-Core Itanium Tukwila
8-Core Xeon Nehalem-EX
AMD K10
POWER6
Itanium 2 with 9MB cache
AMD K10
Six-Core Opteron 2400
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

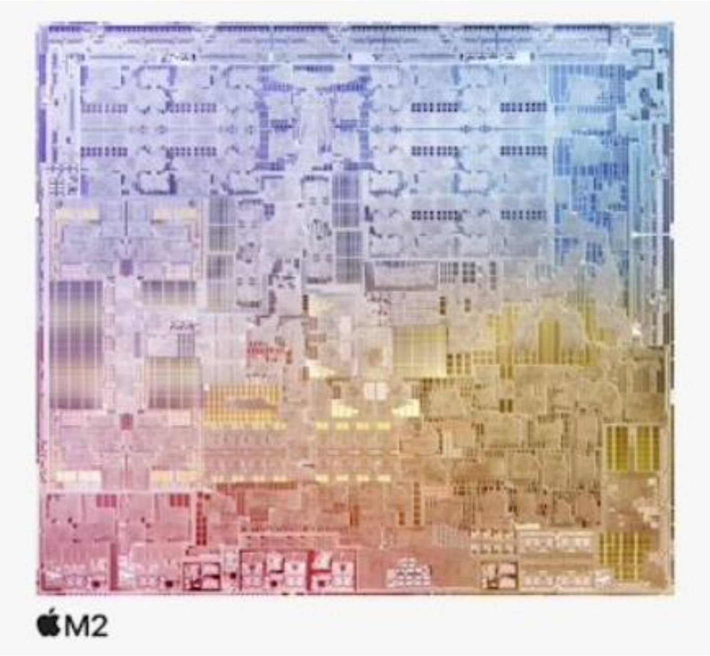

Performance (SPEC Int)
10000
1000
100
10
1
SUN-4/260
MIPS M/120
MIPS M2000
IBM RS6000
DEC AXP/500
HP 9000/750
DEC Alpha 4/266
IBM POWER 100
DEC Alpha 5/300
DEC Alpha 21264/600
DEC Alpha 5/500
DEC Alpha 21264A/667
Intel Xeon/2000
Intel Pentium 4/3000
1987
1989
1991
1993
1995
1997
1999
2001
2003
Year

Then and Now

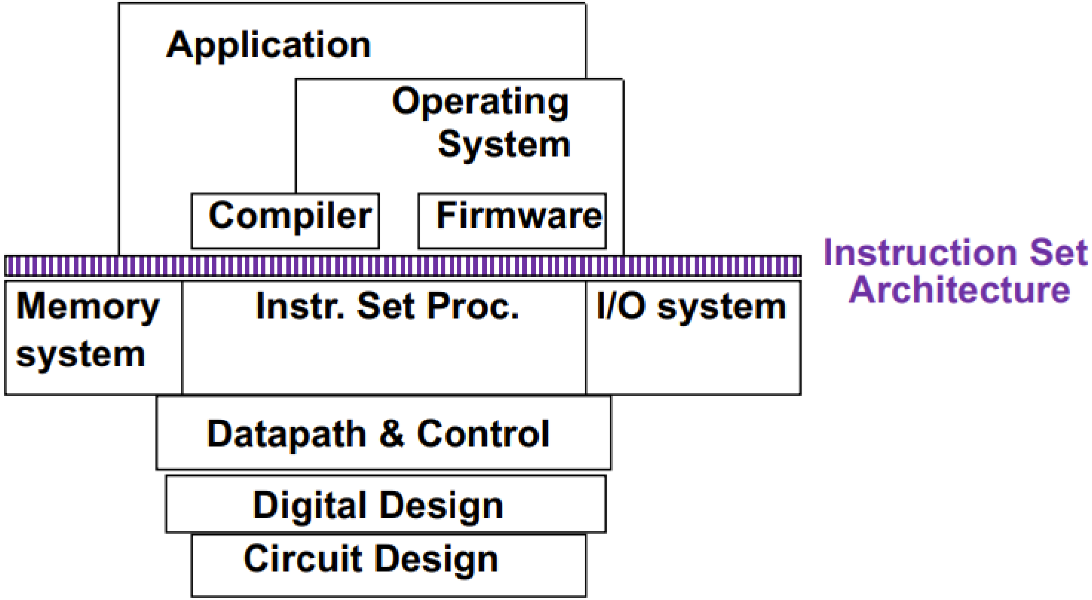
- The first Transistor
- One workbench at AT&T Bell Labs
- 1947: Bardeen, Brattain, and Shockley



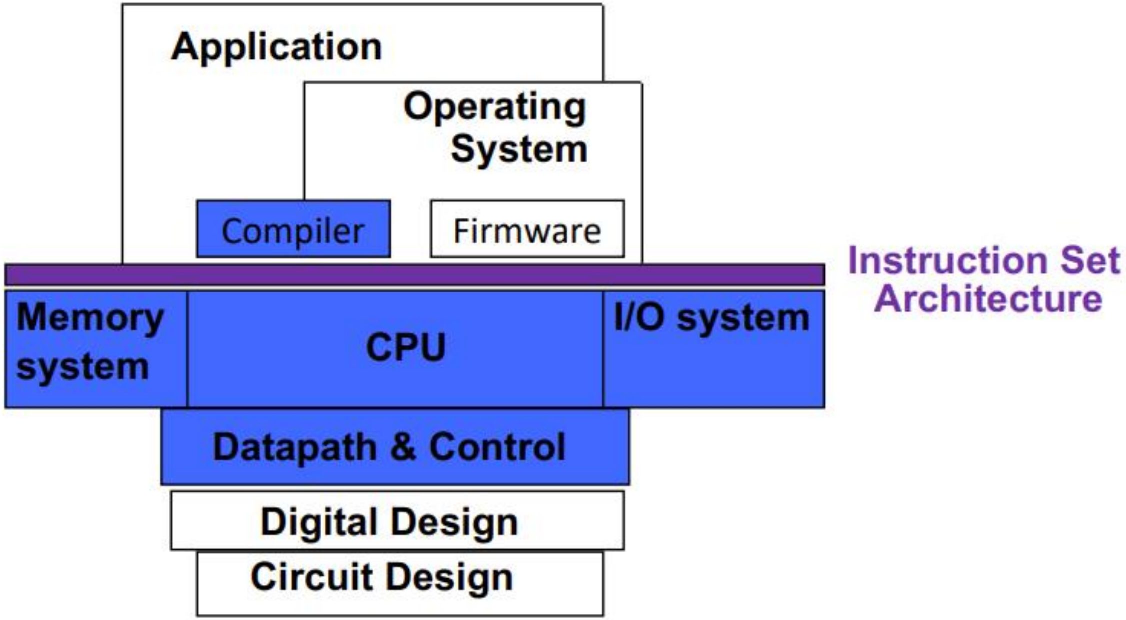
- Apple M2
- 10s of Billions of transistors



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



Compilers and 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

RISC V:
Instruction Set Architecture (ISA)

assembler

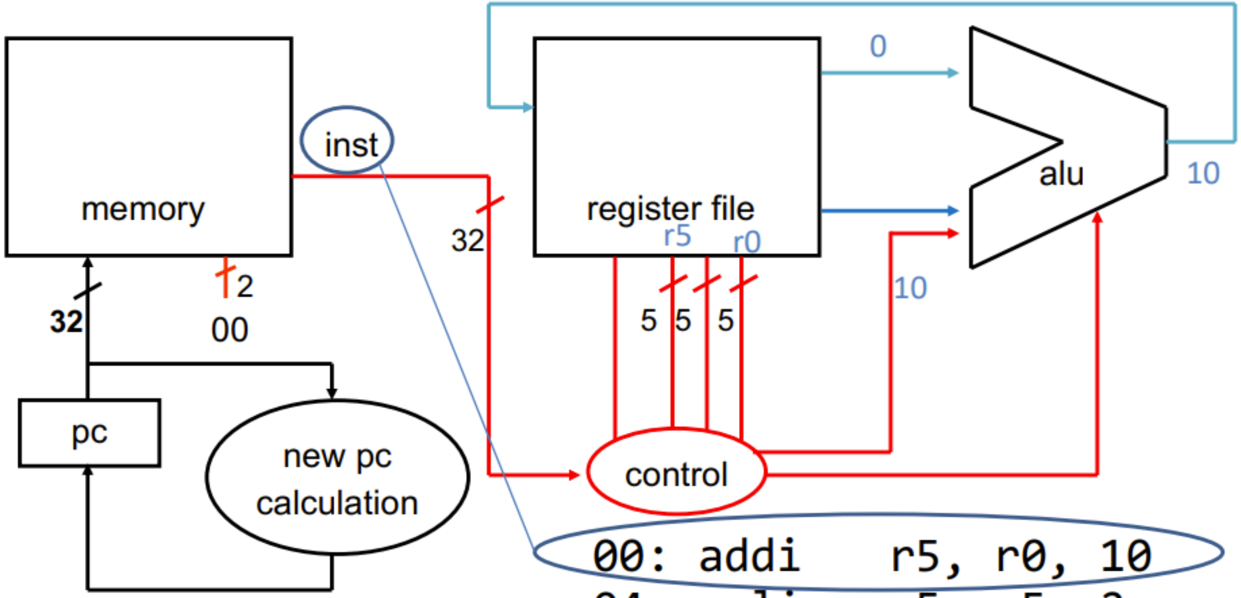
~~MIPS~~ machine language

op = addi r0 r5 10

```
00100000000001010000000000001010
00000000000000101001010000100000
00100000101001010000000000001111
```

op = addi r5 r5 15

Simple Processor




```
00: addi   r5, r0, 10
04: muli   r5, r5, 2
08: addi   r5, r5, 15
```

Don’t need to memorize this!

References

- https://www.cs.cornell.edu/courses/cs3410/2018fa/schedule/slides/01-intro.pdf
- https://www.britannica.com/biography/Joseph-Marie-Jacquard
- https://cse.umn.edu/cbi/who-was-charles-babbage
- https://www.newyorker.com/tech/annals-of-technology/ada-lovelace-the-first-tech-visionary