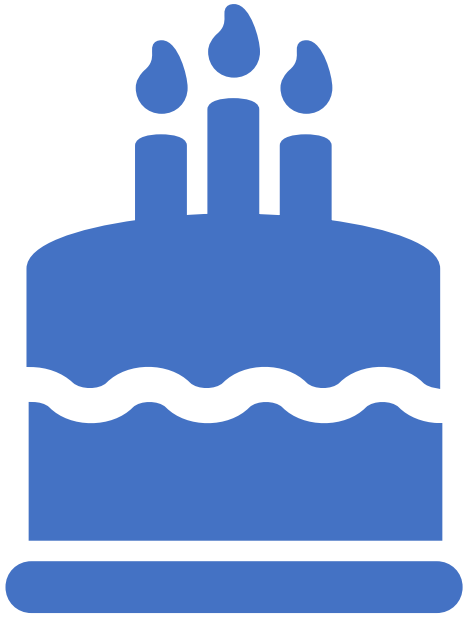
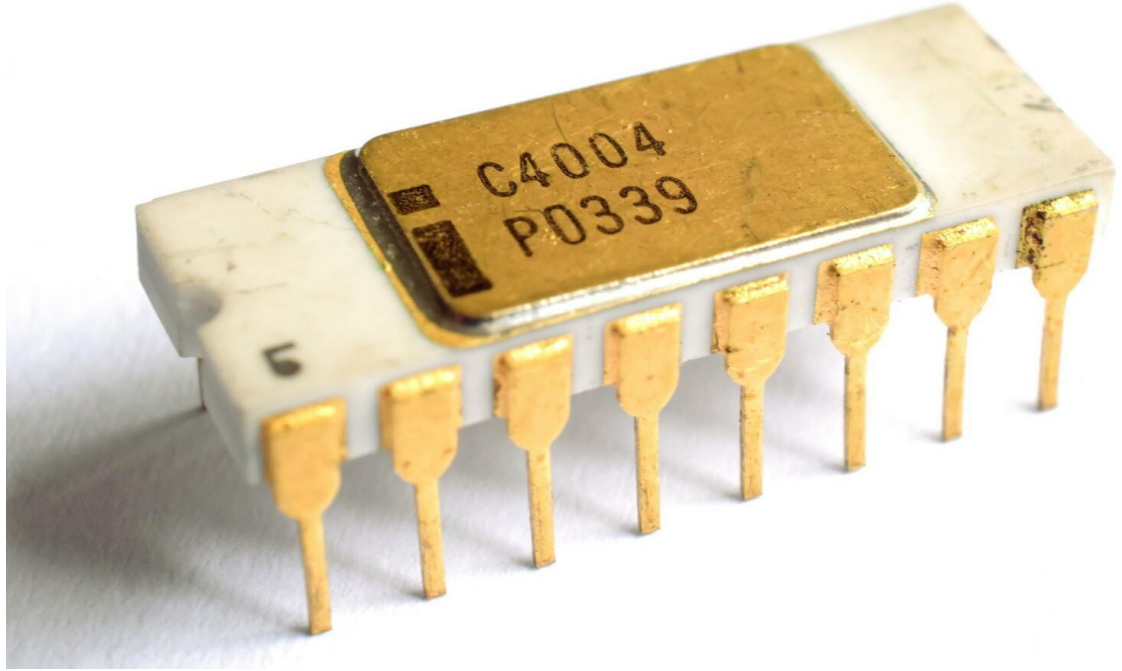
Happy 50th Birthday Microprocessor

Biswa@CSE-IITB

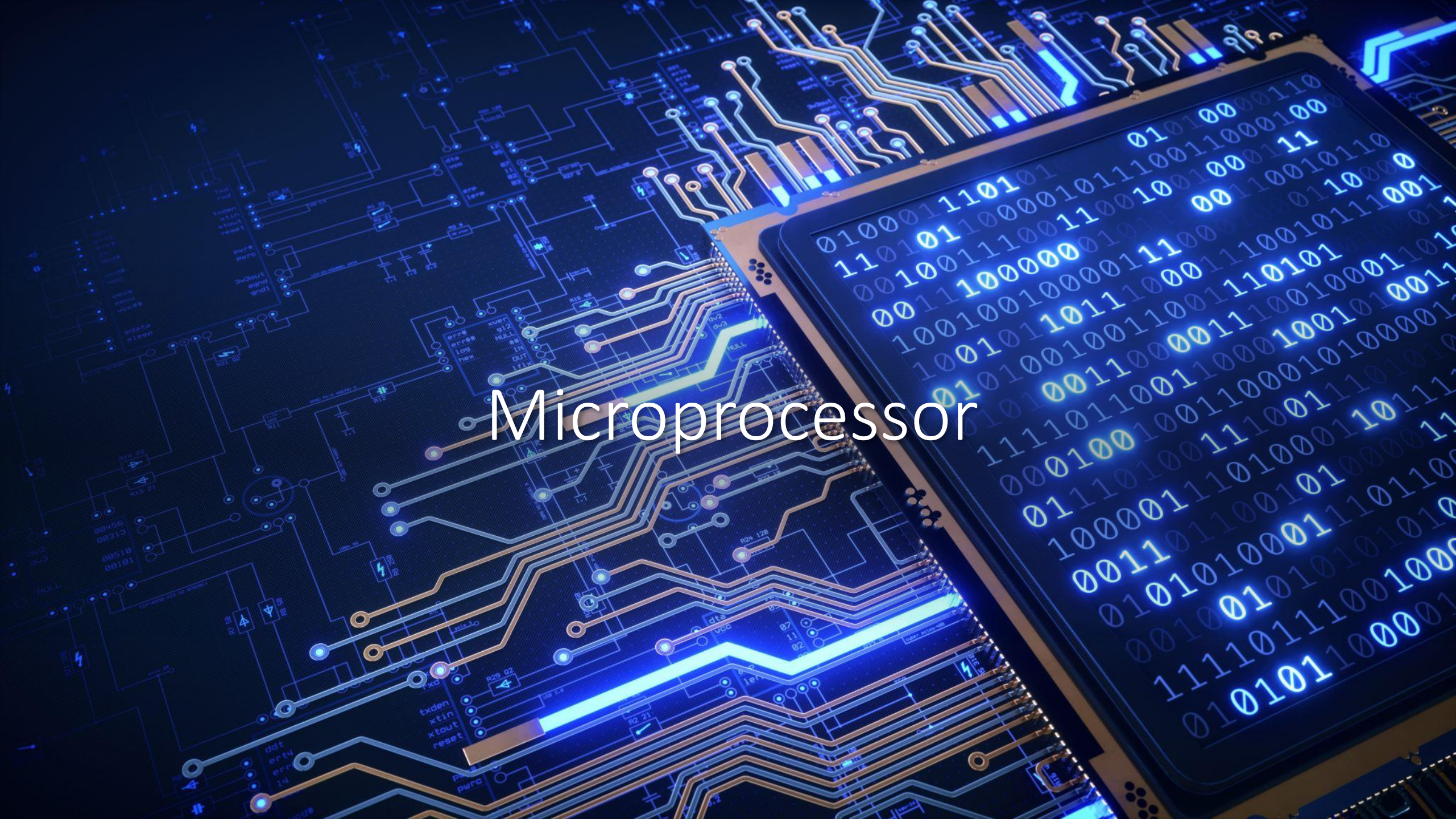
https://www.cse.iitb.ac.in/~biswa/

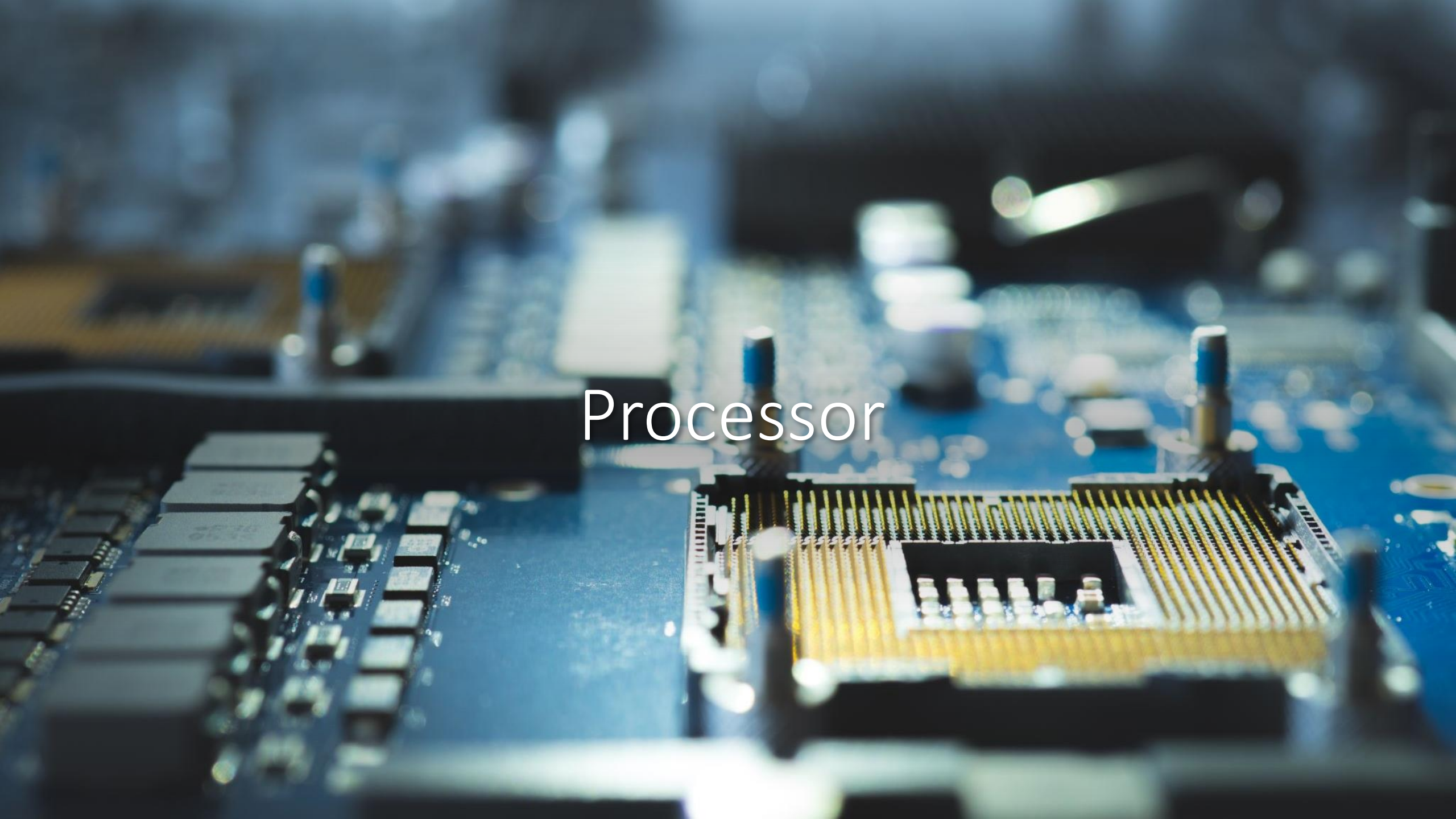




Phones on Silence, Thanks


Birthday


Microprocessor


Processor

Food Processor?

Processor everywhere

Processor: Computing World

Process data and instructions

Data and Instructions?

Program:

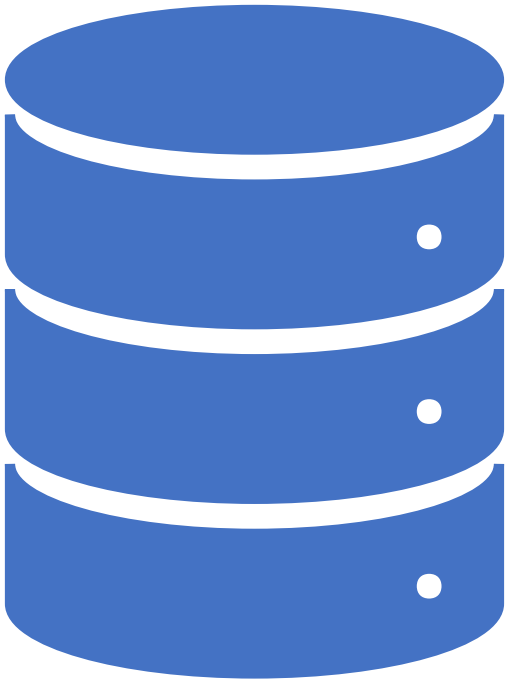
data as input, say an array of numbers

Stored in memory ☺

Instructions:

add, sub, multiply etc

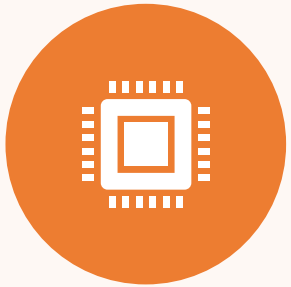
Memory?



Hang on! Same as Calculator, right?

Hang on! Same as Calculator, right? No

More on “instructions”



How can a programmer interact with the processor?

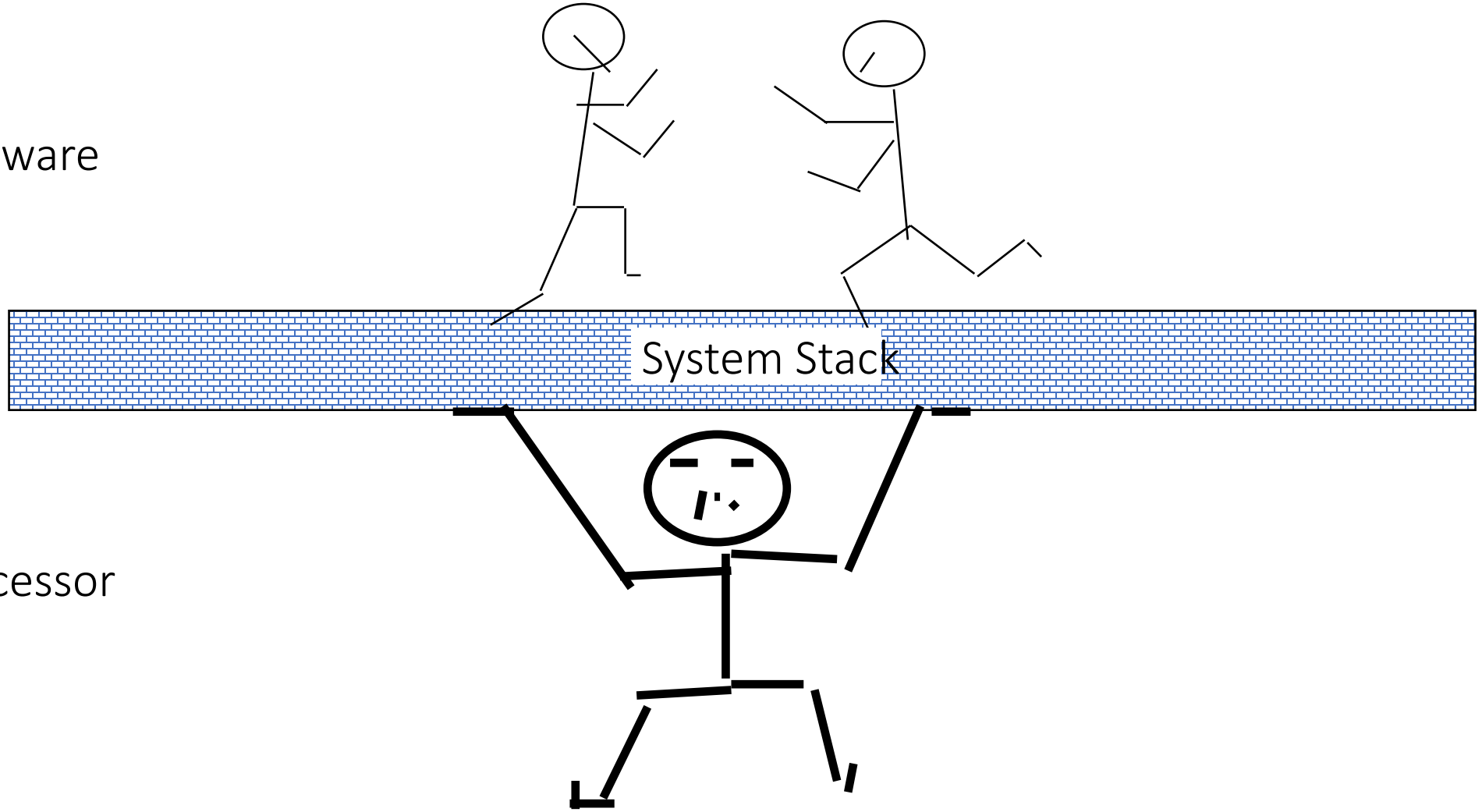
The language of computer: Instructions

Instructions have a vocabulary called instruction set

Driven by instruction set architecture (ISA)

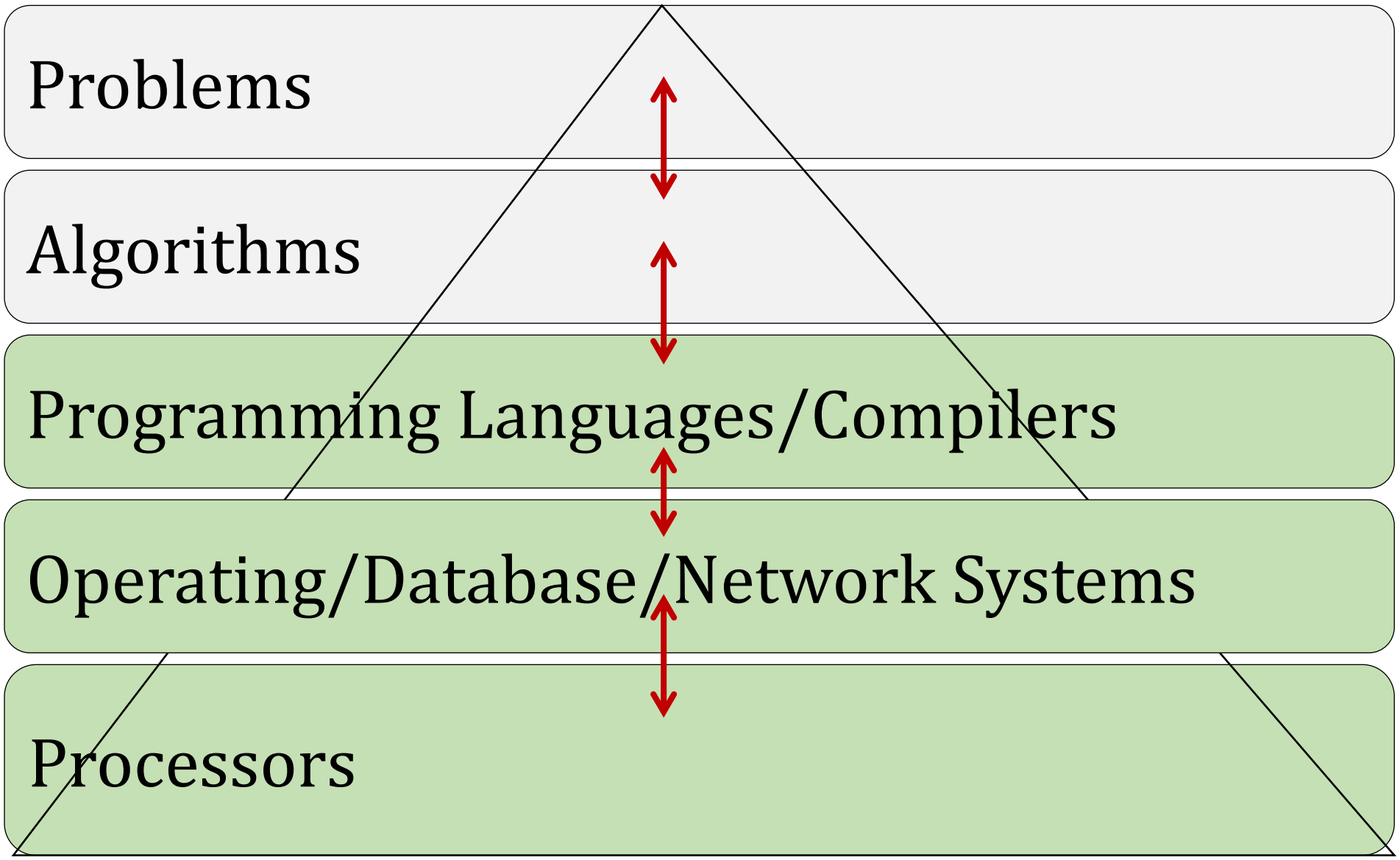
Heavy Lifting

Software



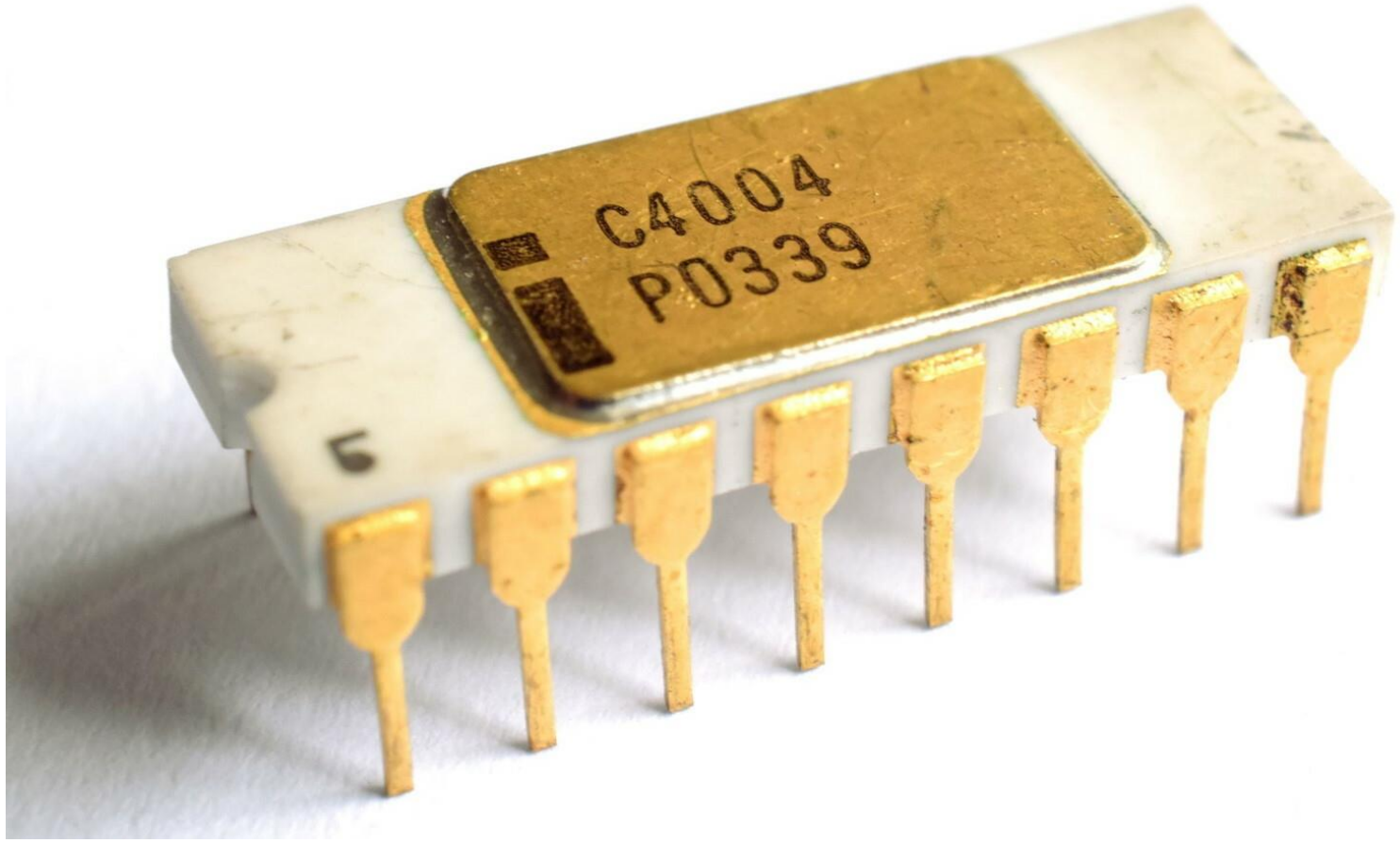
Processor

Computing Stack



The World with no abstractions

000000 00000 00000 00010 00000 100101
000000 00000 00101 01000 00000 101010
000100 01000 00000 00000 00000 000011
000000 00010 00100 00010 00000 100000
001000 00101 00101 11111 11111 111111
000010 00000 10000 00000 00000 000001



Happy 1st Birthday
(Intel 4004, 1971)

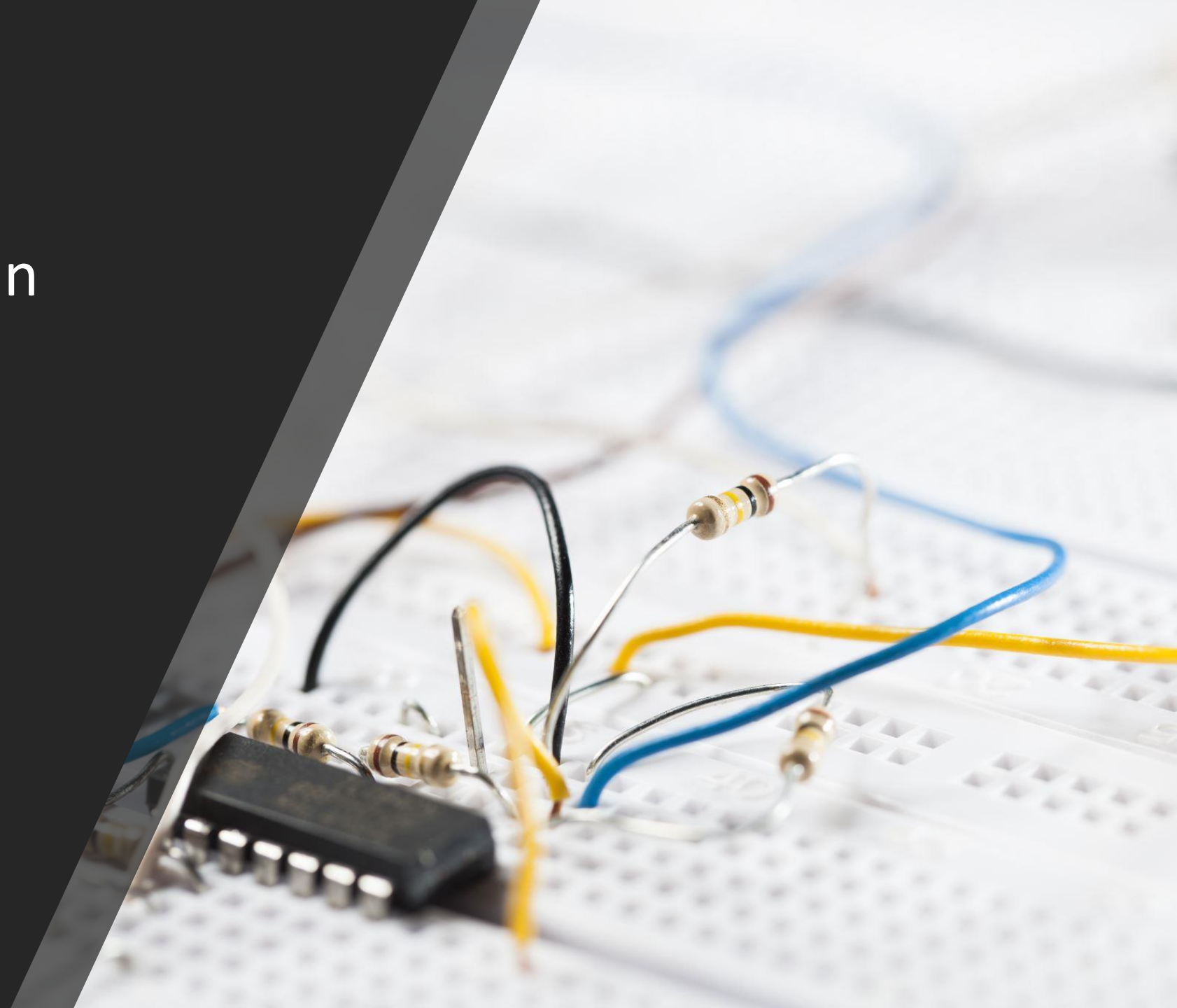
#transistors: 2300
Memory: 4000 bytes

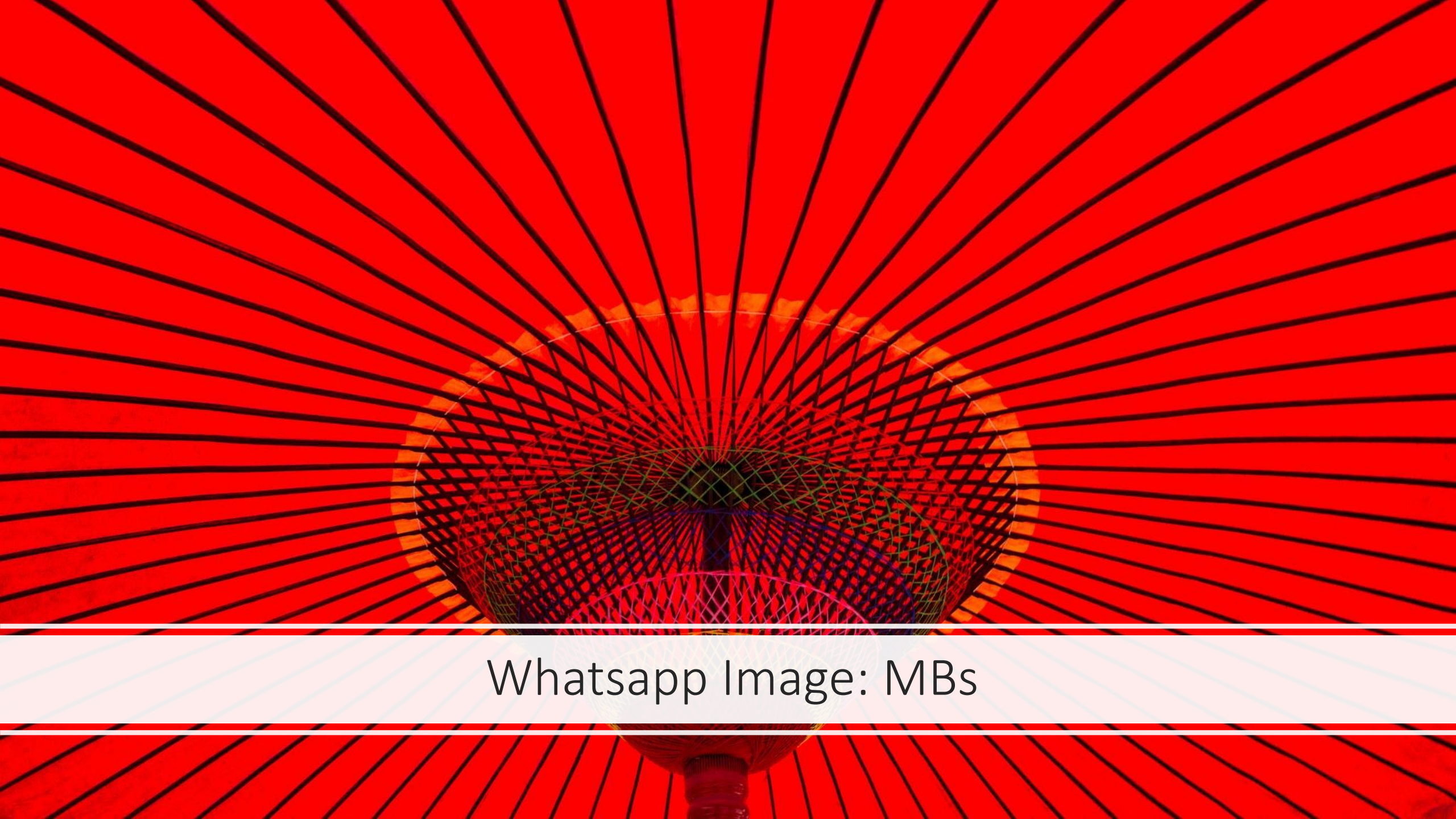
Transistor

Acts like a switch in the digital world

1 : Switch is ON

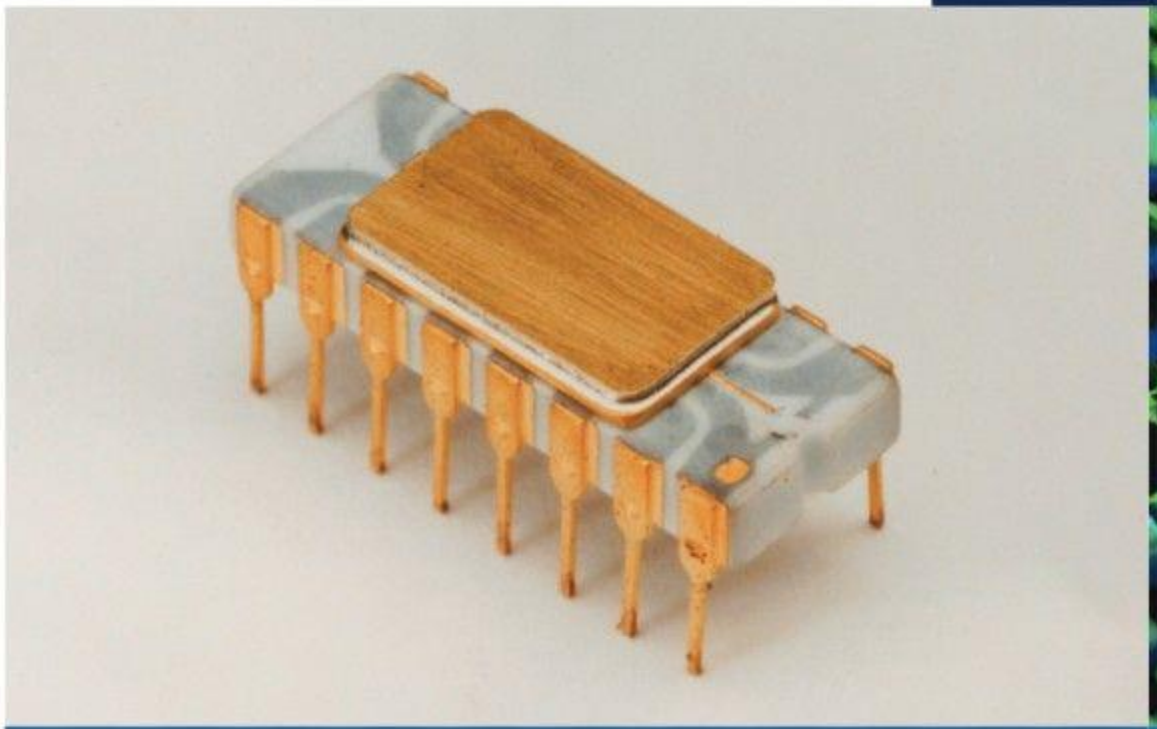
0: Switch is OFF



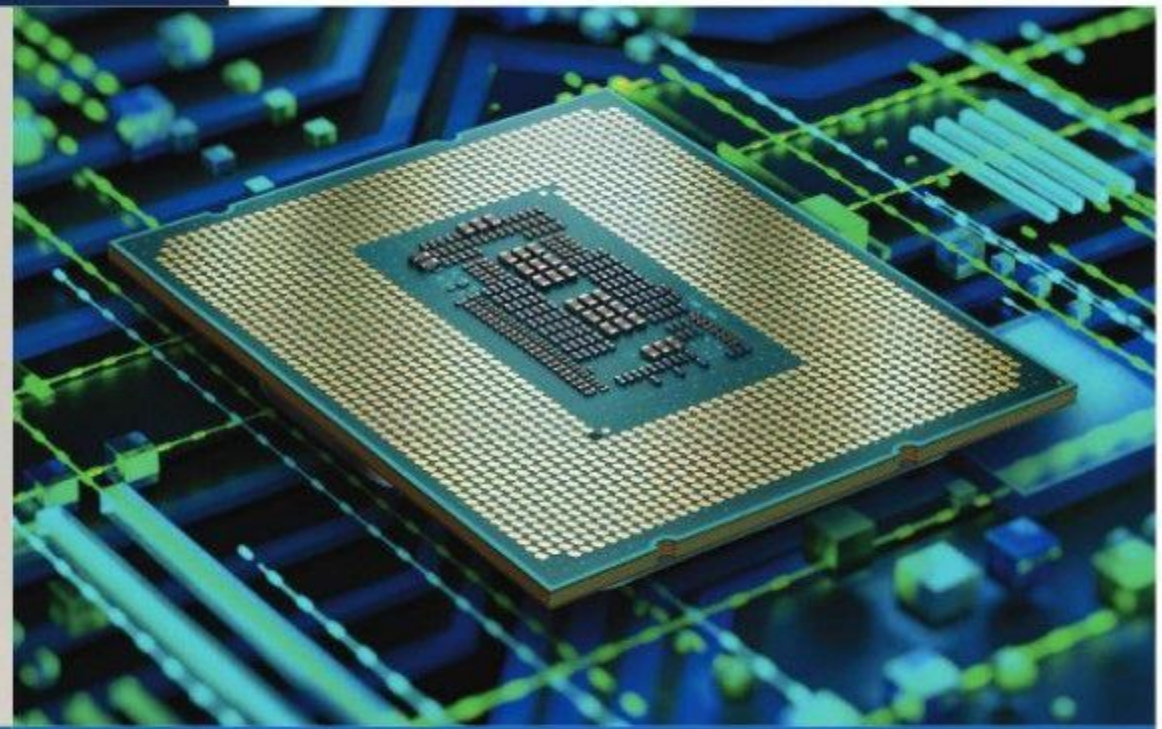


Whatsapp Image: MBs

1971 vs. 2021

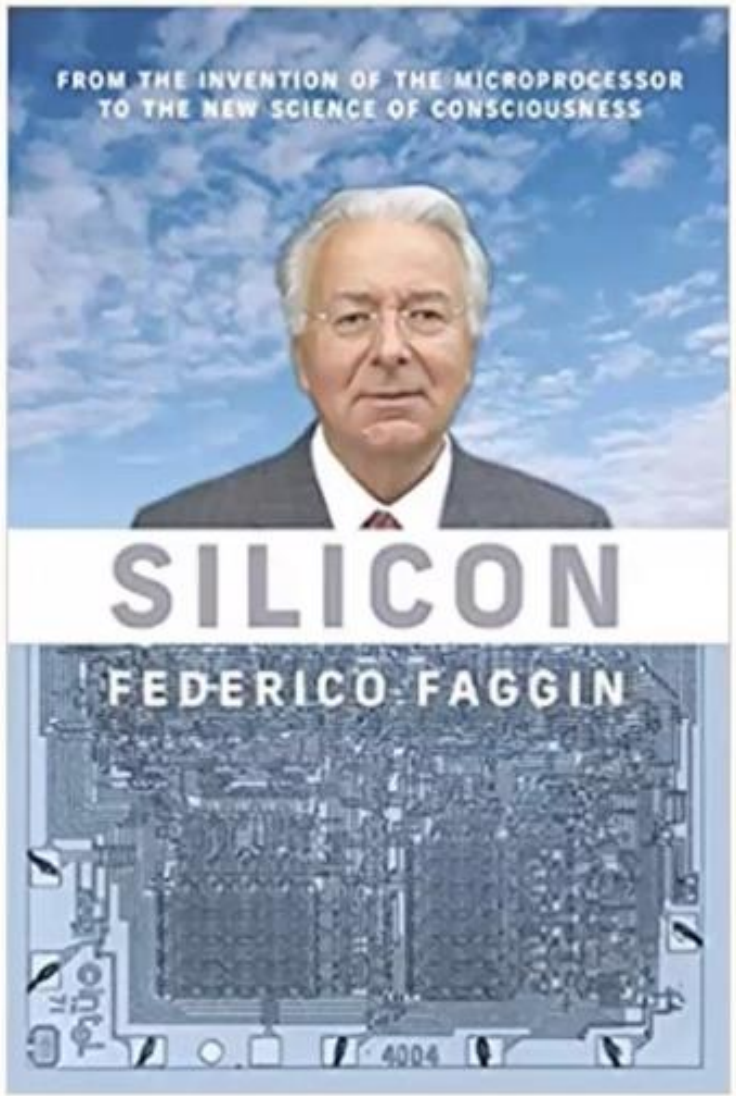


Intel® 4004



12th Generation Intel® Core™ processor family

50 billion transistors in 50 years



Life can only be understood backward, but must be lived forward.

—Soren Kierkegaard

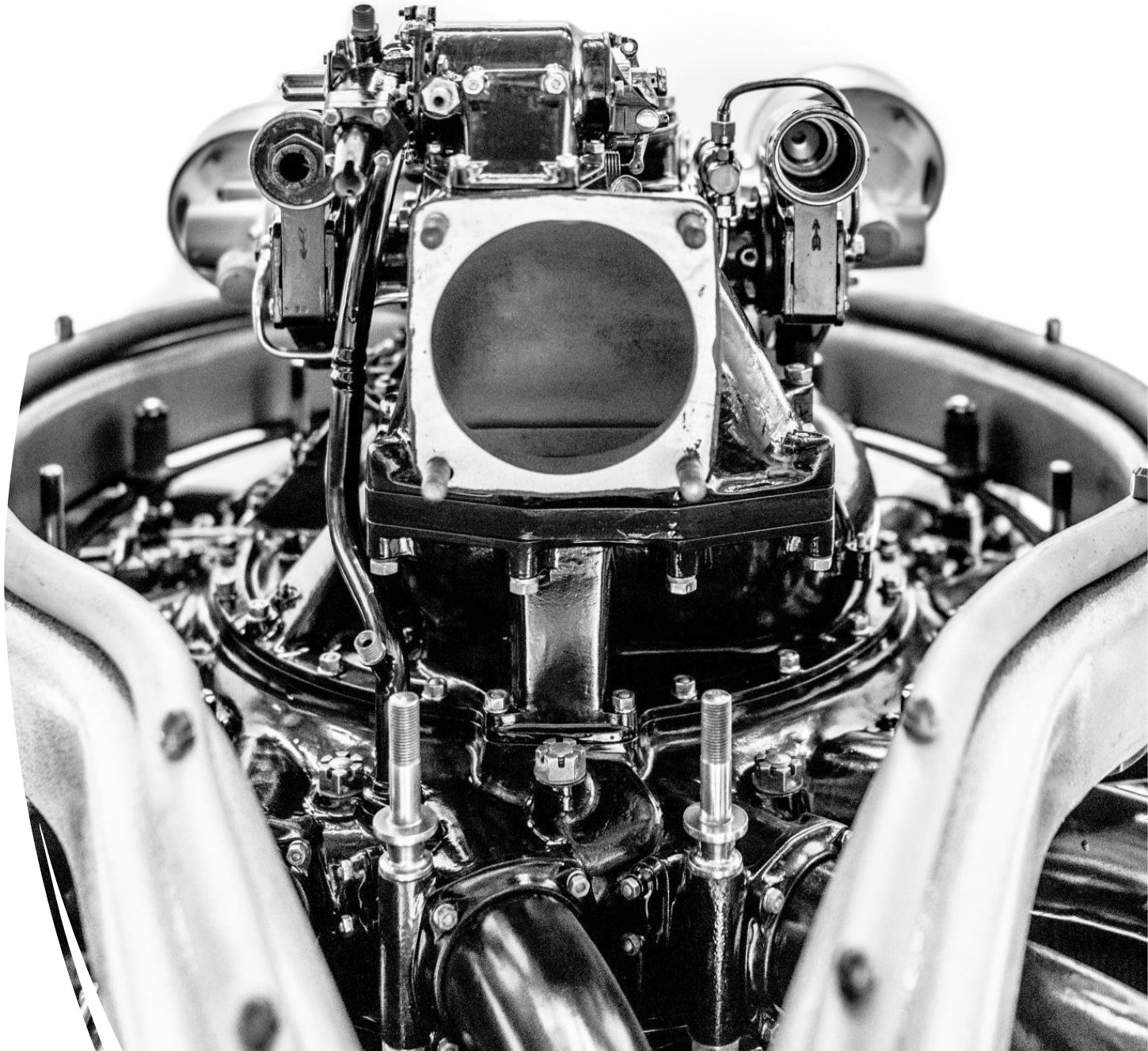
Faggin, Federico. Silicon: From the Invention of the Microprocessor to the New Science of Consciousness. Waterside Productions.

What about Pre-1970?

1800s: Charles Babbage – Difference Engine (conceived in 1823, first implemented in 1855 by Scheutz) – Analytic Engine, the first conception of a general-purpose computer (1833, never implemented)

1890: Tabulating machines

Early 1900s: Analog computers

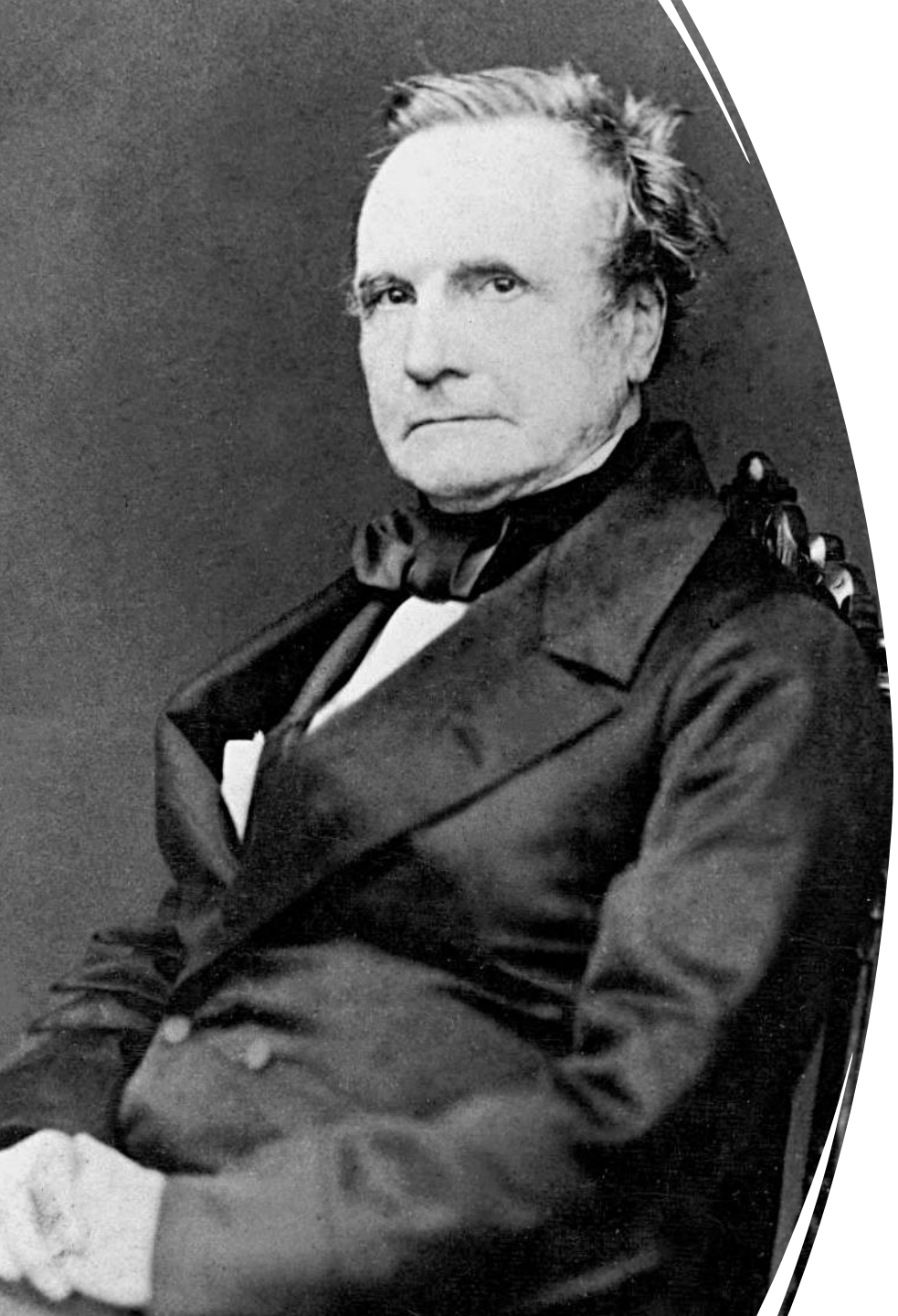


Analog Computers

[Marsyas, Creative Commons BY-SA 3.0]

Antikythera mechanism c.100BC

- Represents problem variables as some physical quantity (e.g., mechanical displacement, voltage on a capacitor) and uses scaled physical behavior to calculate results



Charles Babbage (Father of Computer?)

- A true “polymath” with interests in many areas
- Frustrated by errors in printed tables, wanted to build machines to evaluate and print accurate tables
- Inspired by earlier work organizing human “computers” to methodically calculate tables by hand

1823

- Babbage's paper is published

1834

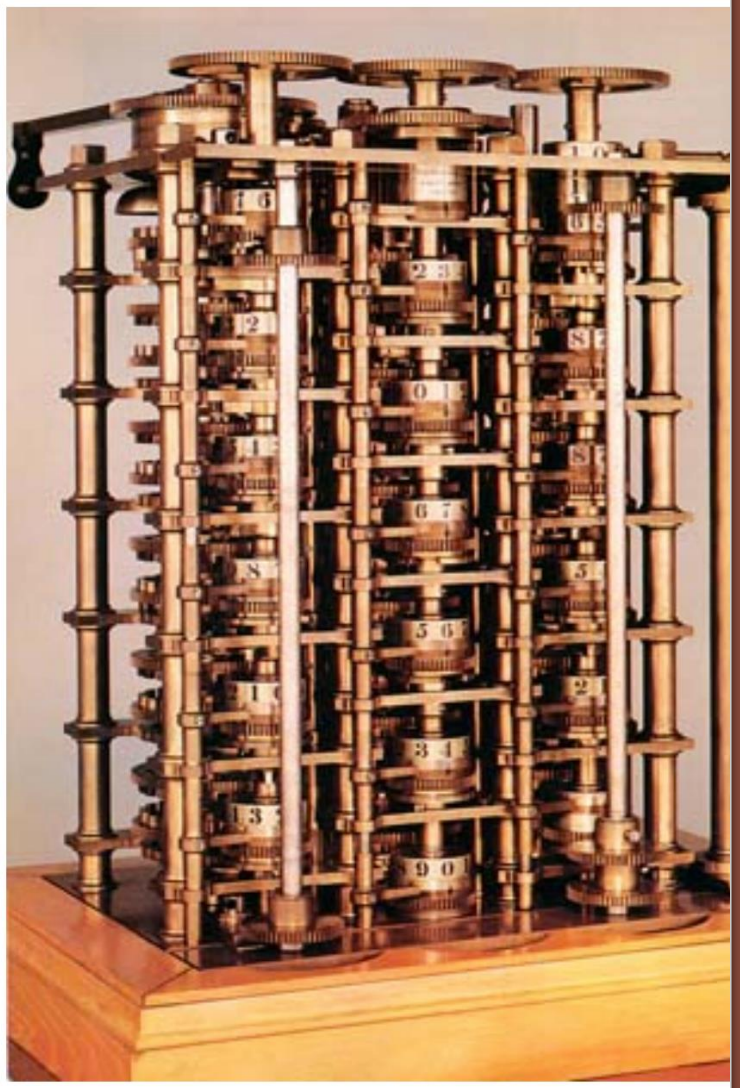
- The paper is read by Scheutz & his son in Sweden

1842

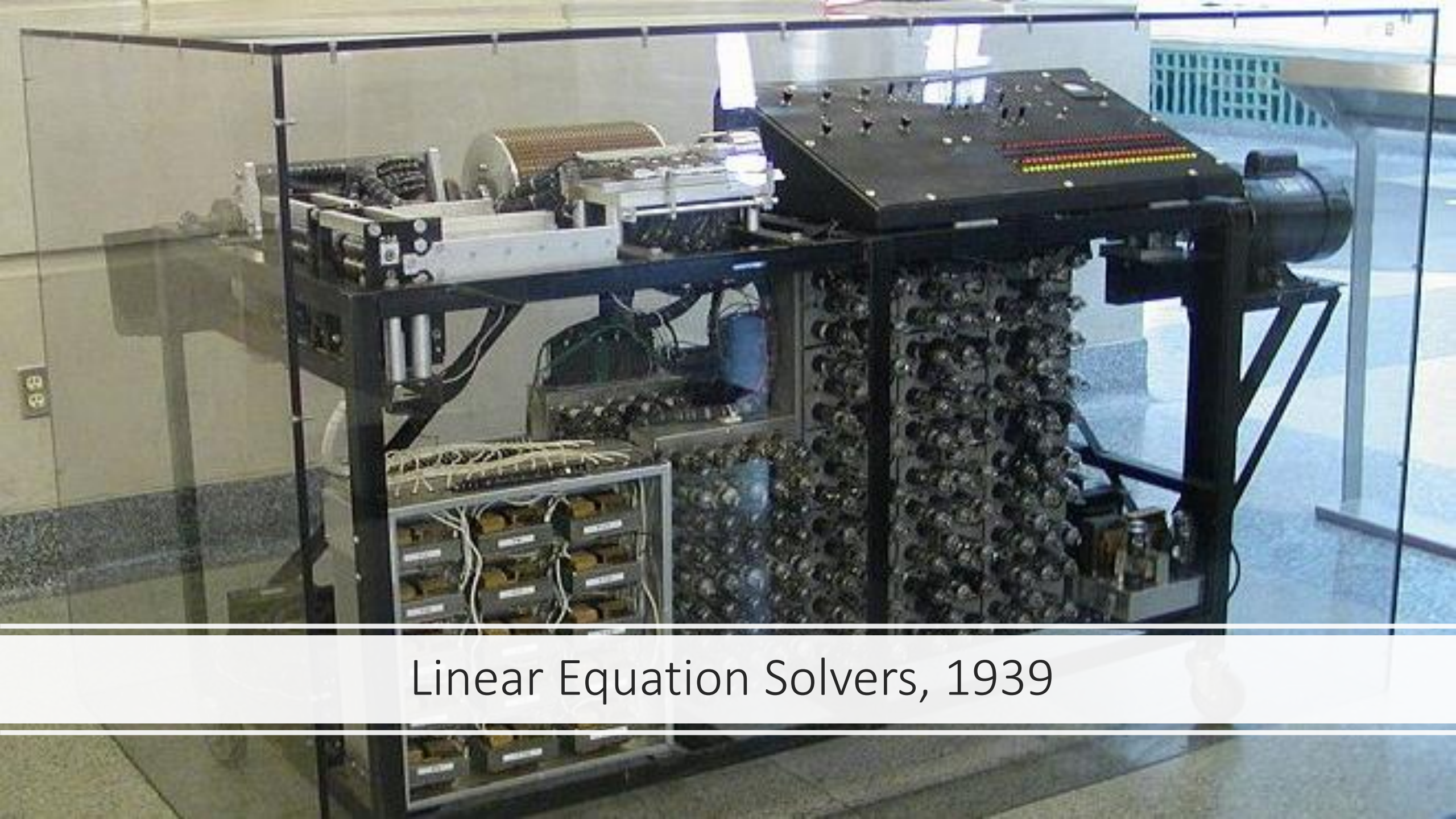
- Babbage gives up the idea of building it; he is onto Analytic Engine!

1855

- Scheutz displays his machine at the Paris World Fare
- Can compute any 6th degree polynomial
- *Speed:* 33 to 44 32-digit numbers per minute!



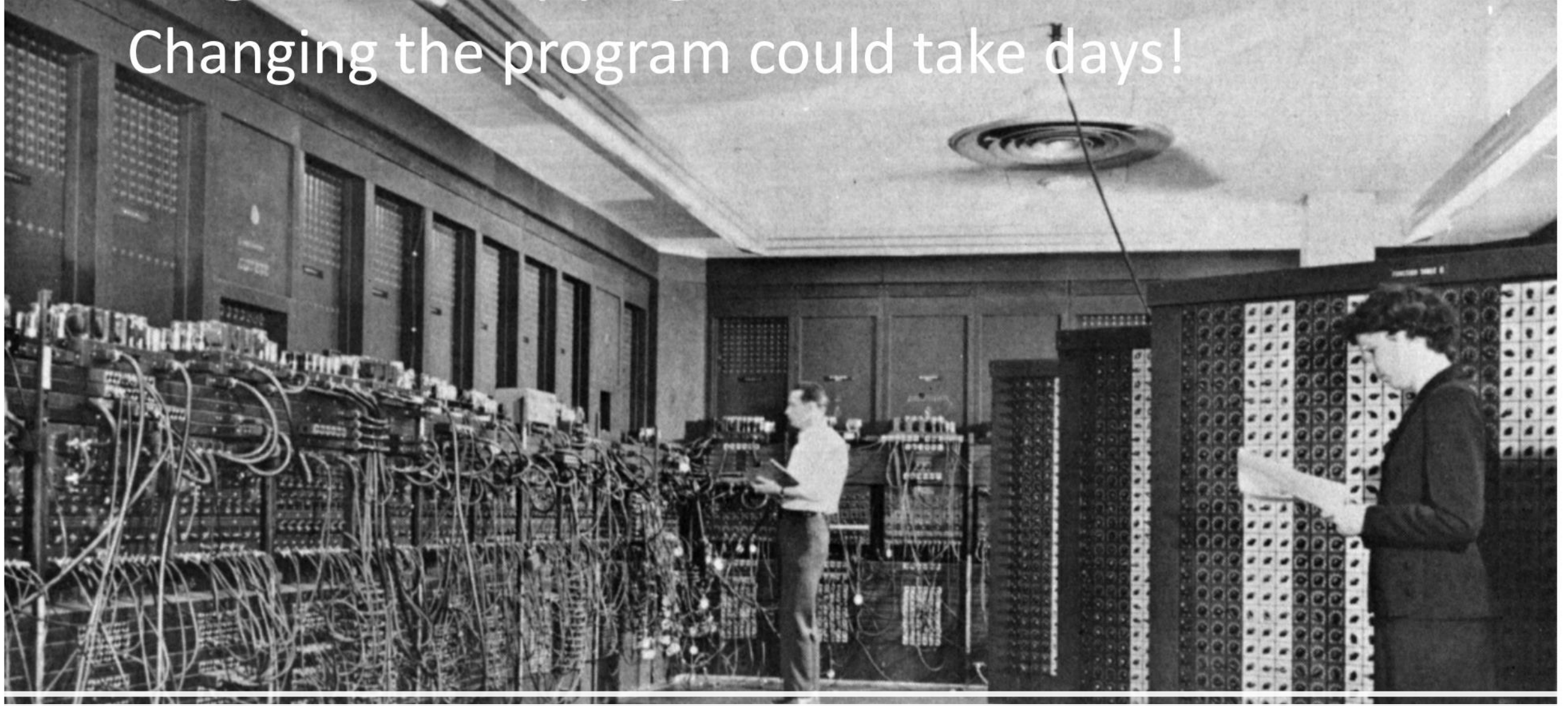
Difference Engine (Tabulate polynomial functions)



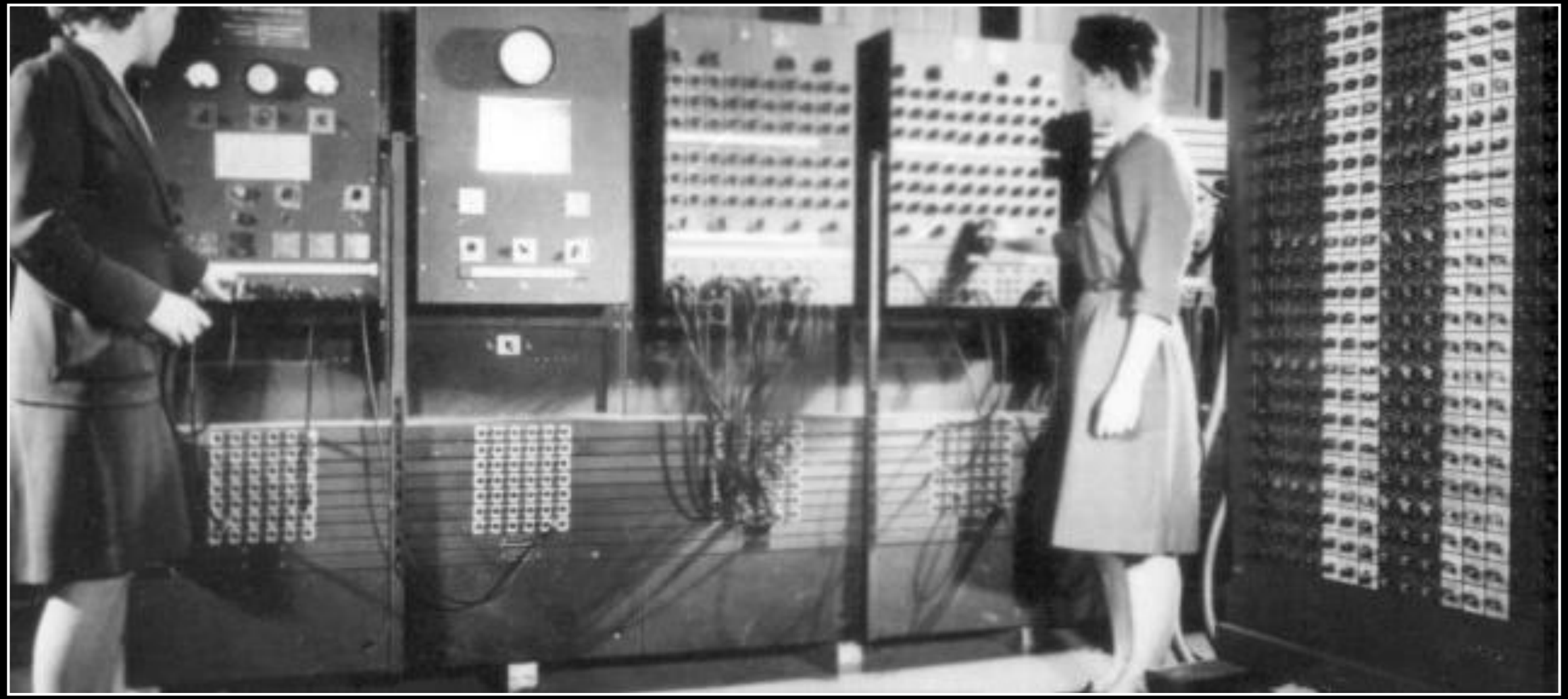
Linear Equation Solvers, 1939

Zuse, During World War-III

Changing the program could take days!



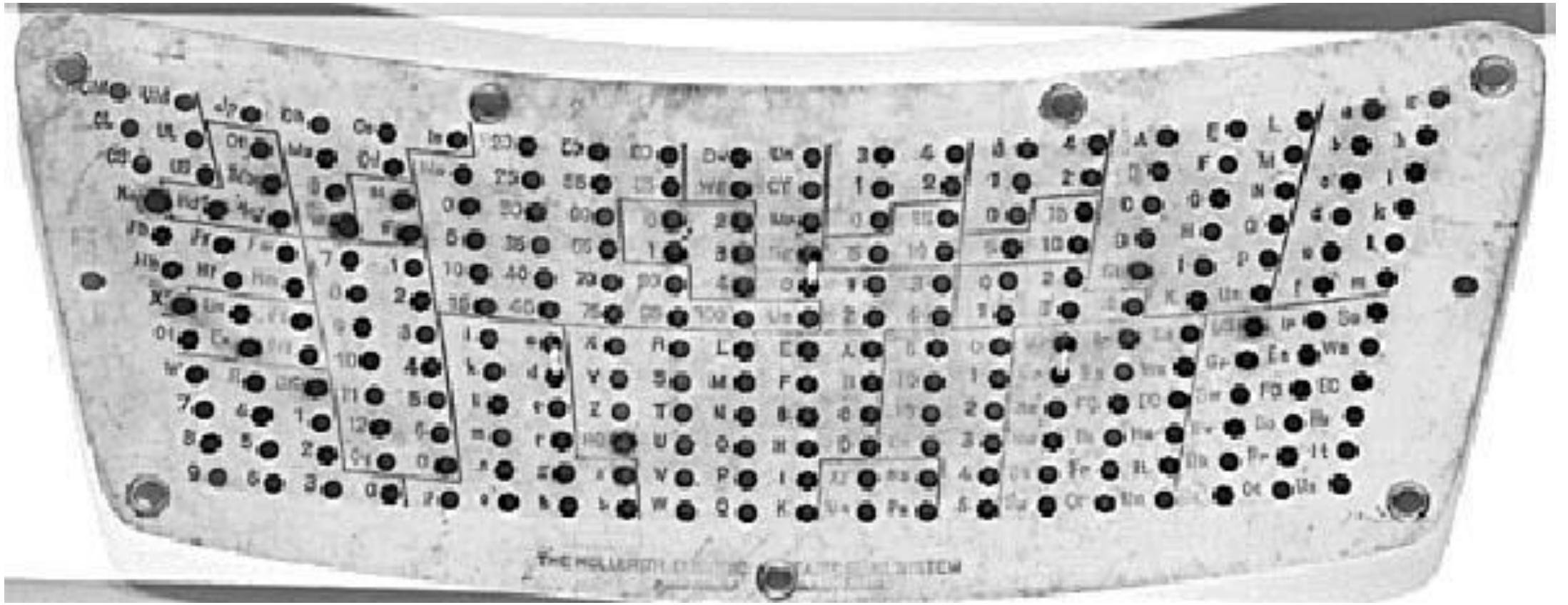
ENIAC, The first general purpose calculator ☺



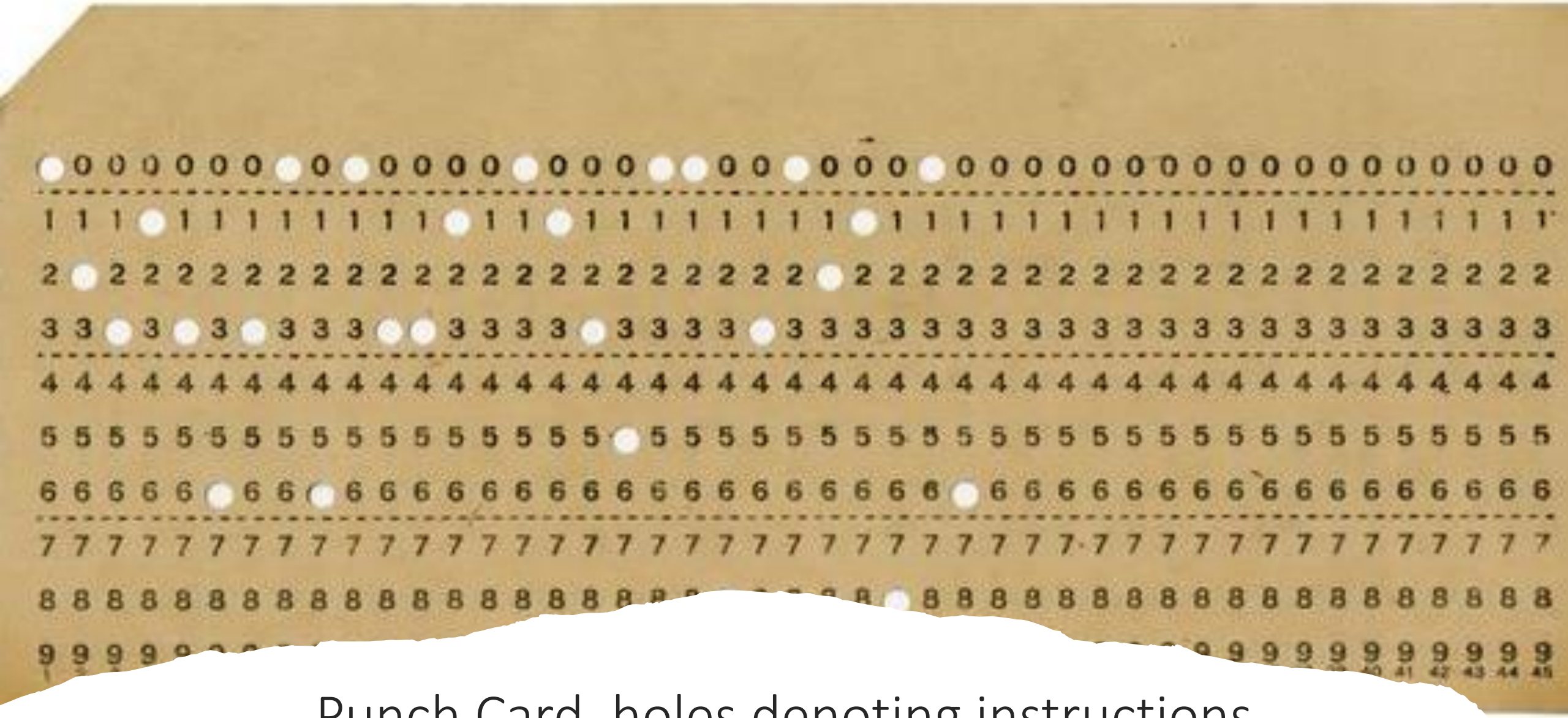
ENIAC girls

Watch the Movie “The Imitation game”

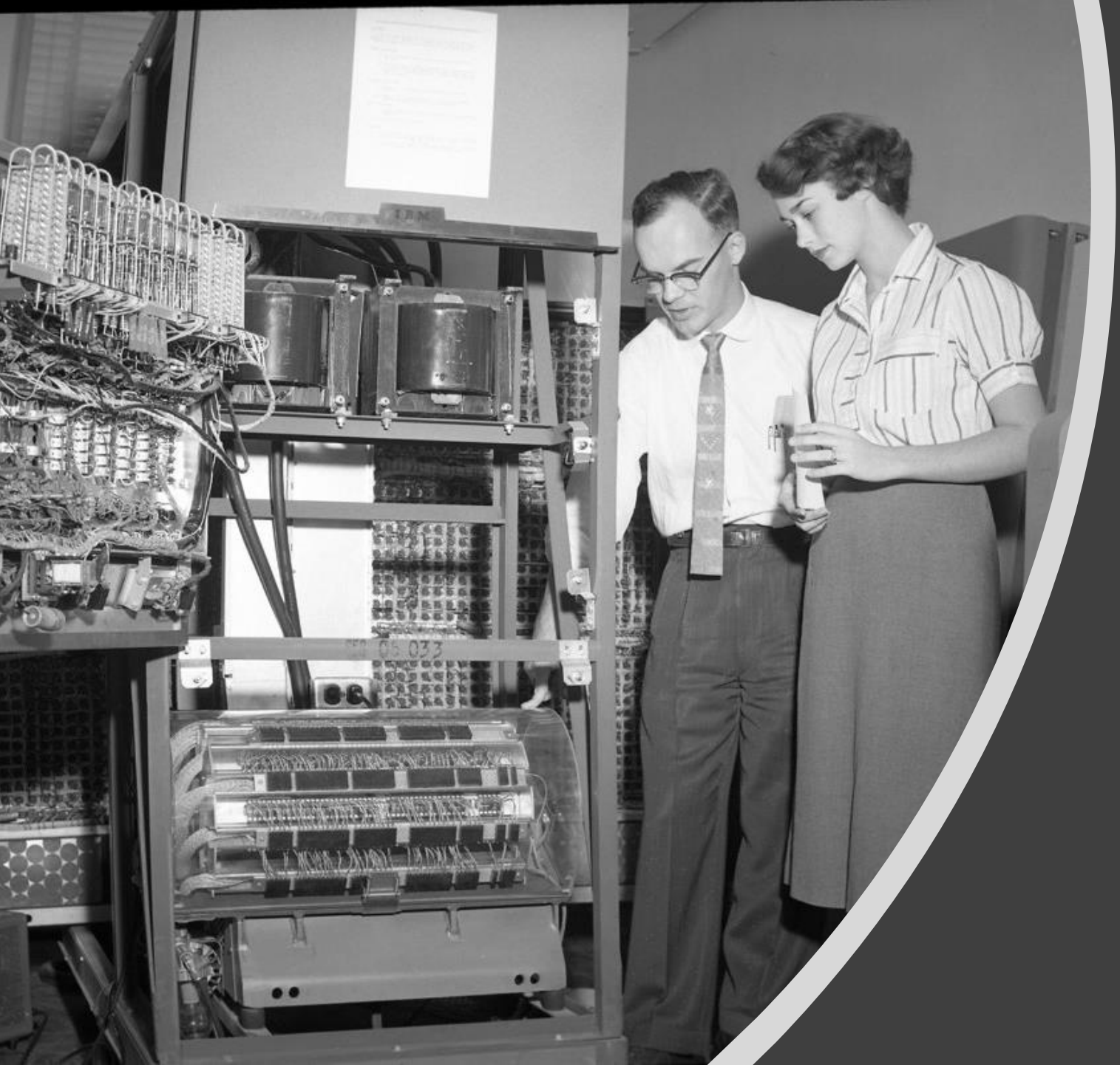
What about data/instructions in those days?



Punch Card

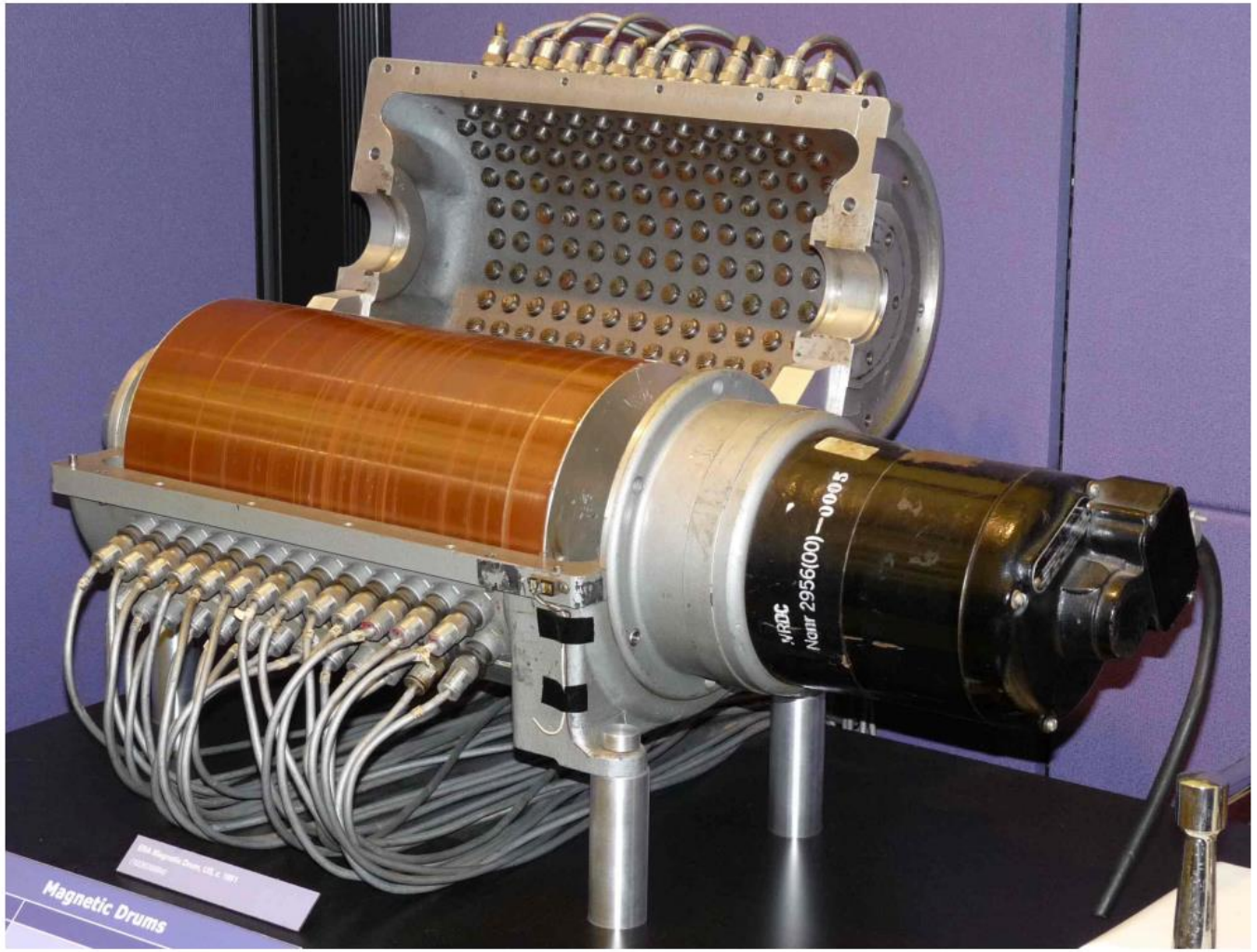


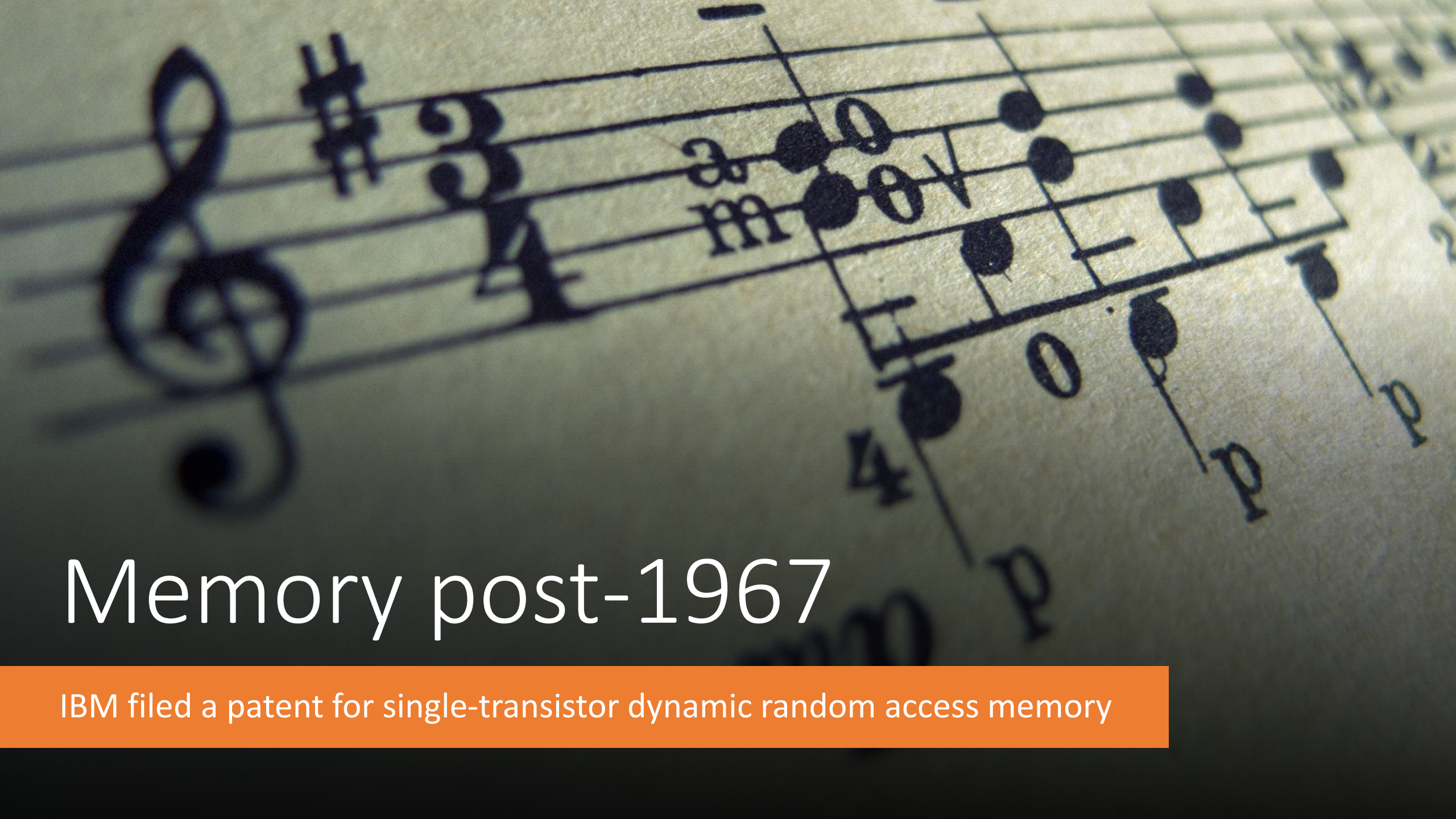
Punch Card, holes denoting instructions



IBM 650, 1953
First mass-produced computer

Programmer's view of IBM 650 (drum machine with 44 instructions)



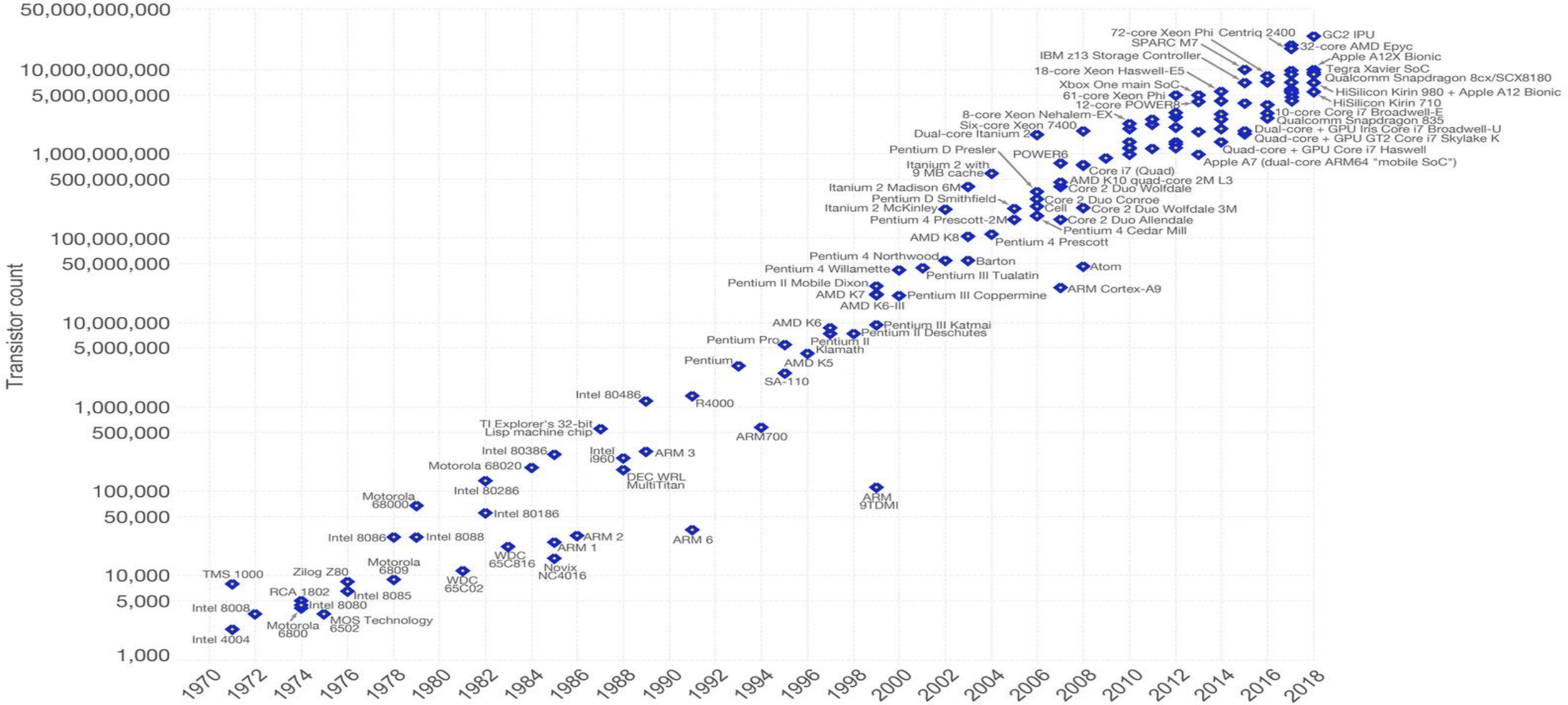


Memory post-1967

IBM filed a patent for single-transistor dynamic random access memory

Moore's Law – The number of transistors on integrated circuit chips (1971-2018)

Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important as other aspects of technological progress – such as processing speed or the price of electronic products – are linked to Moore's law.

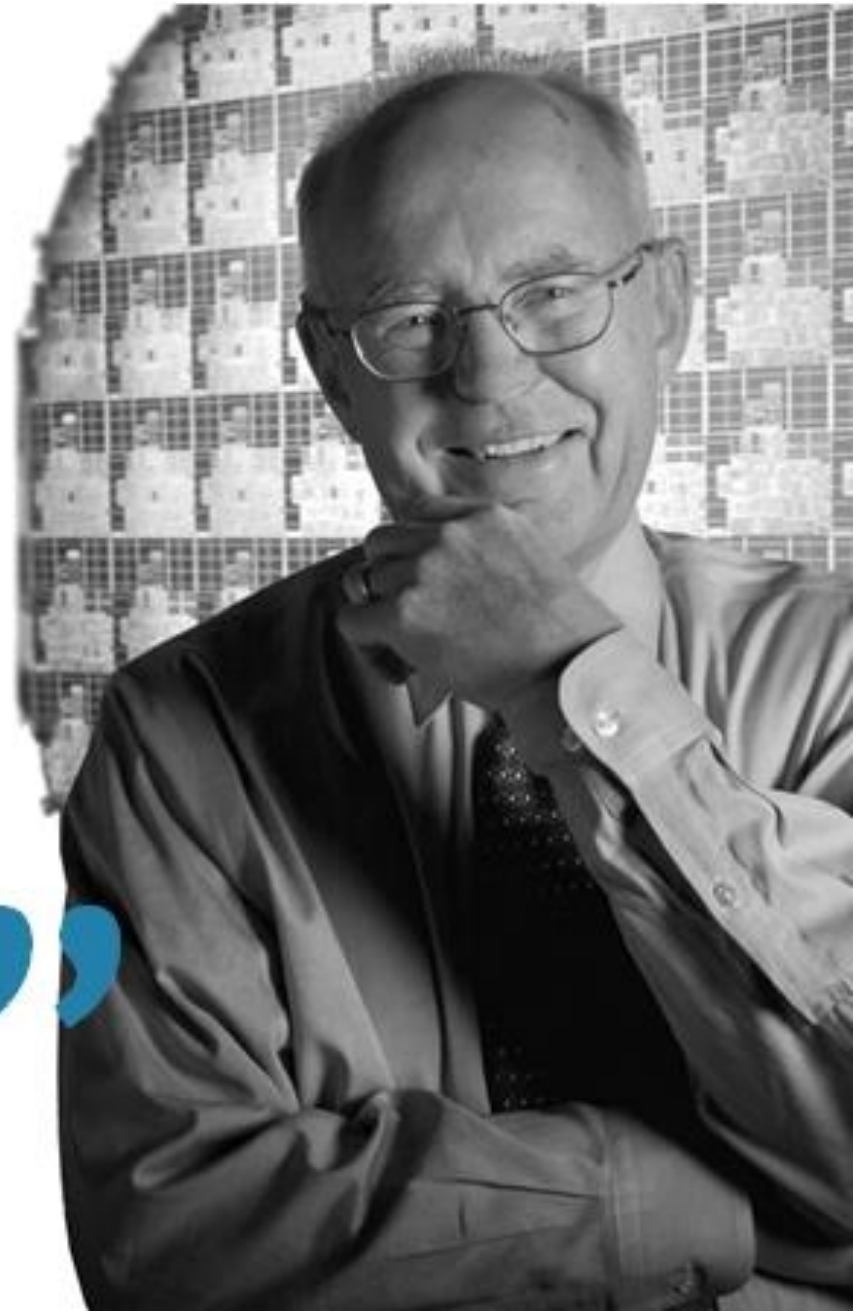


Data source: Wikipedia (https://en.wikipedia.org/wiki/Transistor_count)
The data visualization is available at OurWorldinData.org. There you find more visualizations and research on this topic.

“Frankly, I didn't expect to be so precise.”

Gordon Moore

Intel co-founder and author of Moore's law



RISC Years: 1980 onwards

One instruction quicksort

Or

100 simple instructions

DRAM capacity touched KiB:

2KiB in 1981

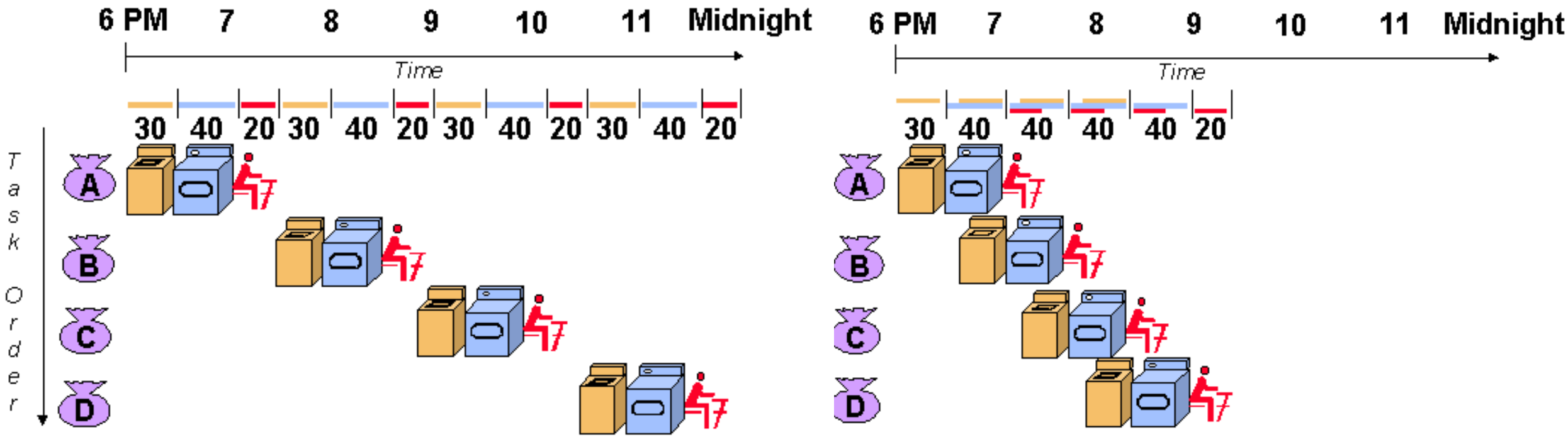
Idea of Pipelining

RISC I: A REDUCED INSTRUCTION SET VLSI COMPUTER

DAVID A. PATTERSON and CARLO H. SEQUIN

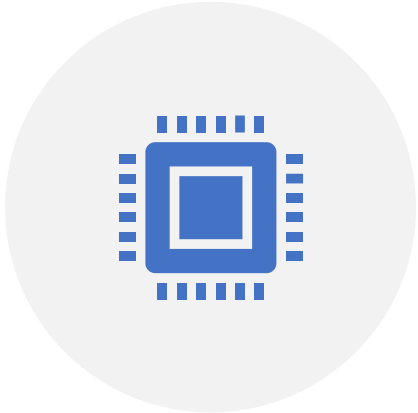
Computer Science Division
University of California
Berkeley, California

Idea of Pipelining and ILP



Personal Computers in 1980s

Intel Pentium



TRANSISTORS: 3 MILLION

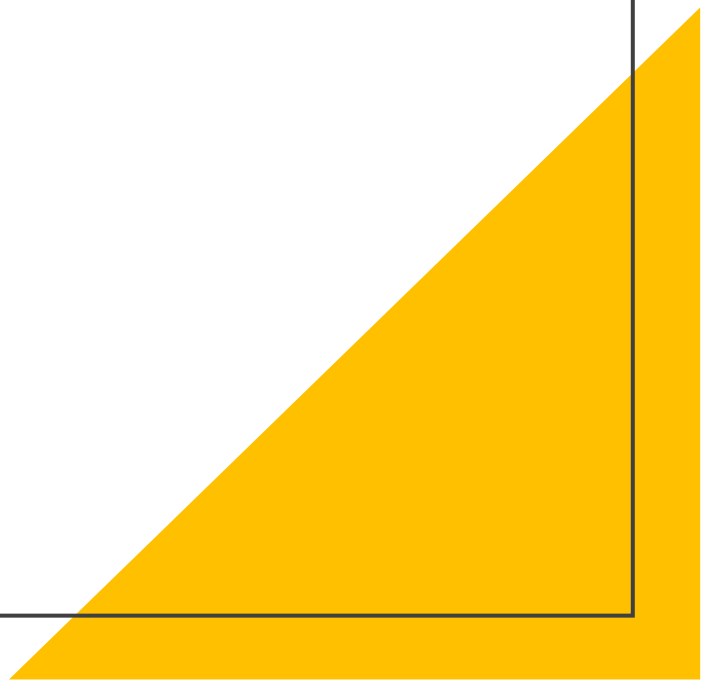
MEMORY : 4 GB

CACHES (FASTER MEMORY) ☺

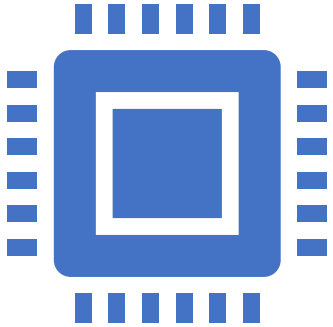
ILP++ years: 1995 to 2005

Instruction level parallelism with out of order execution, speculation, and prediction

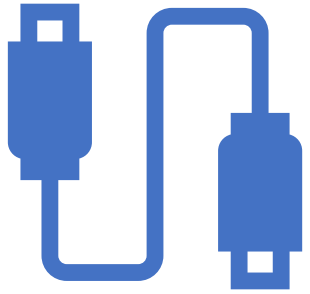
Performance
Performance and
Performance



Intel’s Model: Tick Tock



Tick: Advanced technology, smaller transistors ☺



Tock: Same transistors, new ideas for performance

2005-2015 Welcome to the world of multicores

2015-2023

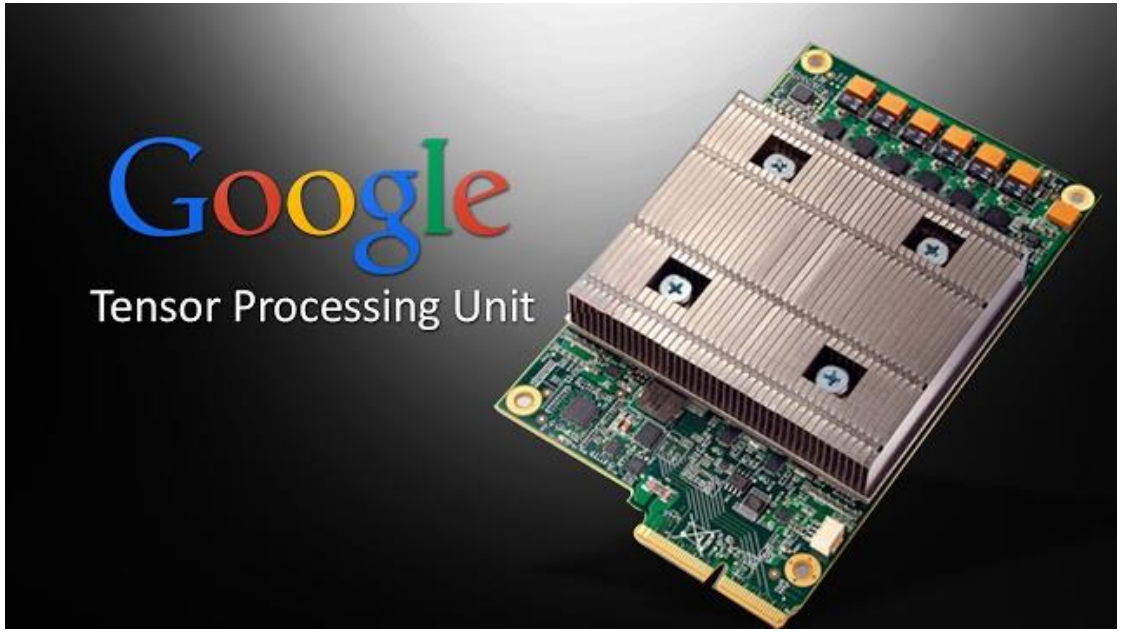
Heterogeneous and Domain Specific Processors

Image Processing

Neural Network

ARM M1 chip, slow and high performing


QUADRO
RTX 5000
NVIDIA


Google
Tensor Processing Unit

Software Companies ~ Hardware Companies

https://www.ai-startups.org/top/hardware/

NEWS > COMPANY NEWS

Facebook Is Reportedly Building its Own Chip

November 17, 2020

Meet the Microsoft Pluton processor – The security chip designed for the future of Windows PCs

GOOGLE MOBILE TECH

Google is reportedly building its own processor for Pixels and Chromebooks

It could be used in Pixels as early as next year

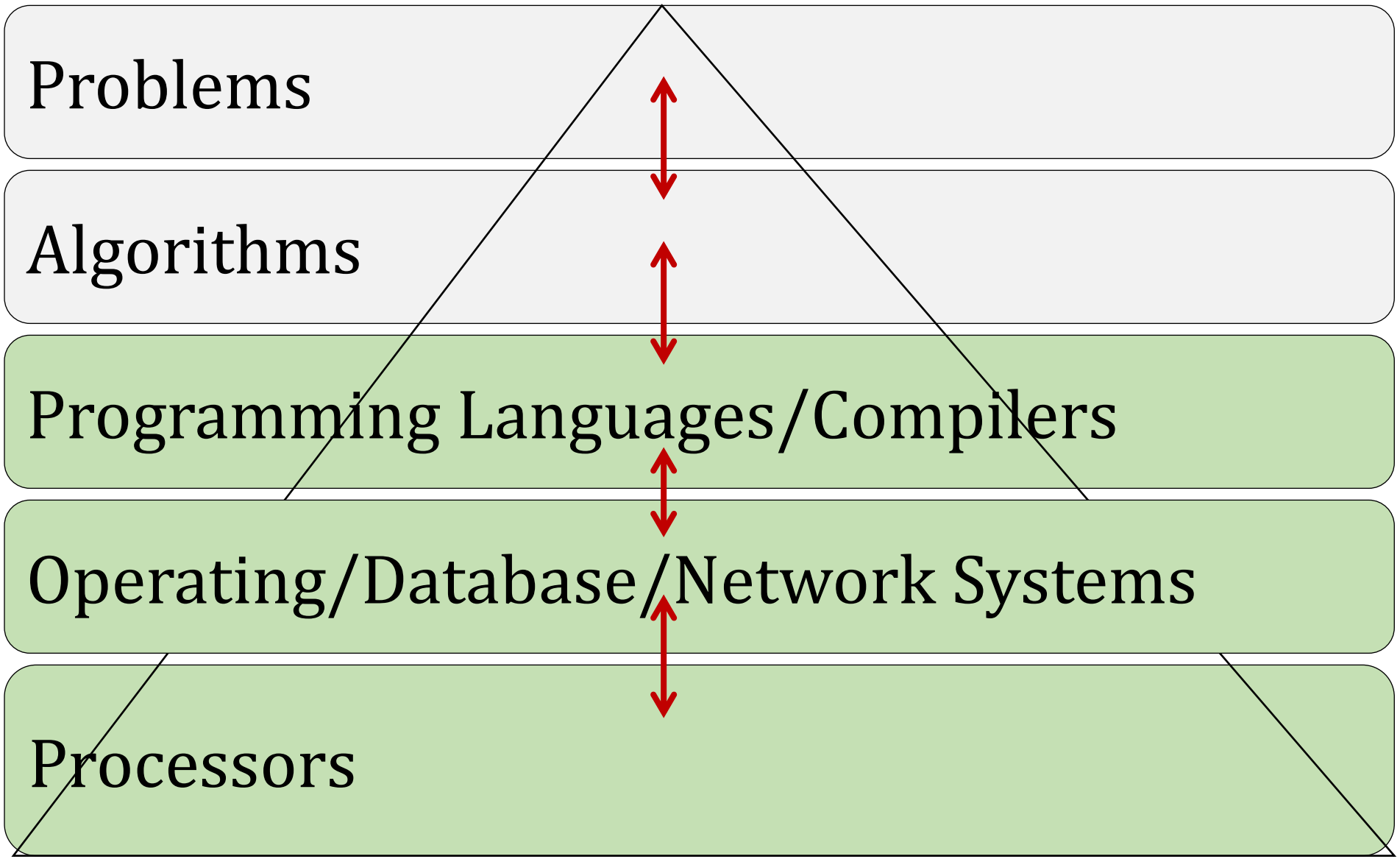
All good? Nah, The Walls

ILP Wall

Power Wall

Memory Wall

Free Lunch is Over



Let's talk to each other

Grow Strong before the 75th Birthday

Thanks for your time