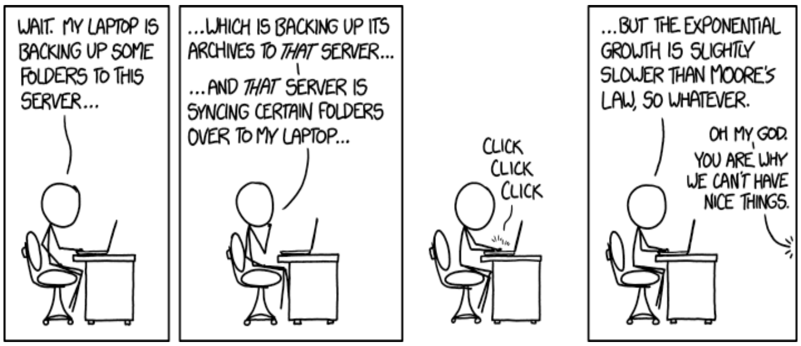
Lecture 2: Technology

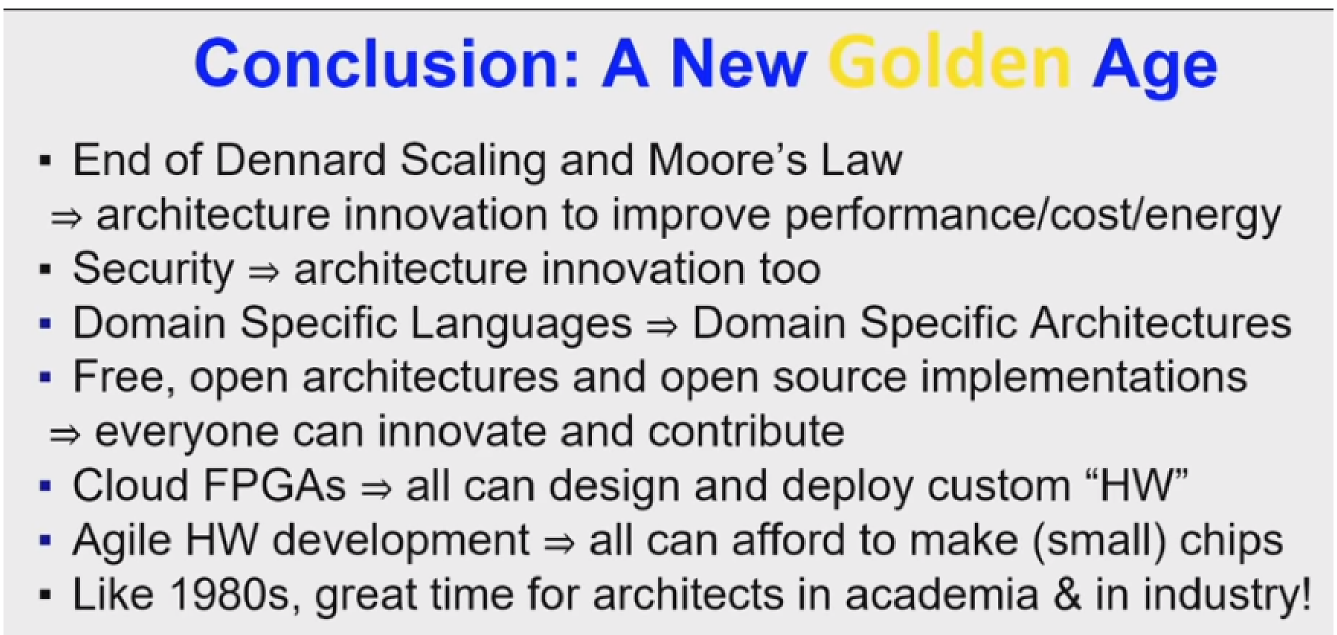
Wednesday, January 9, 2019 7:45 AM

Outline

- Turing Lecture
- Moore's Law and Dennard Scaling
- Energy/Power of CMOS devices
    - Transistor
    - Integration



Turing Lecture

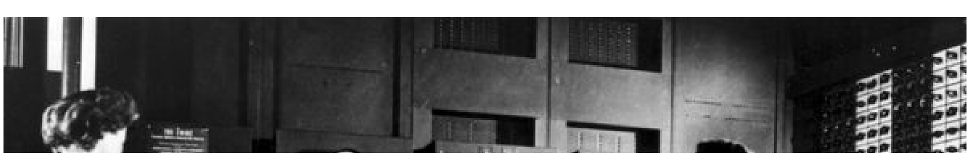


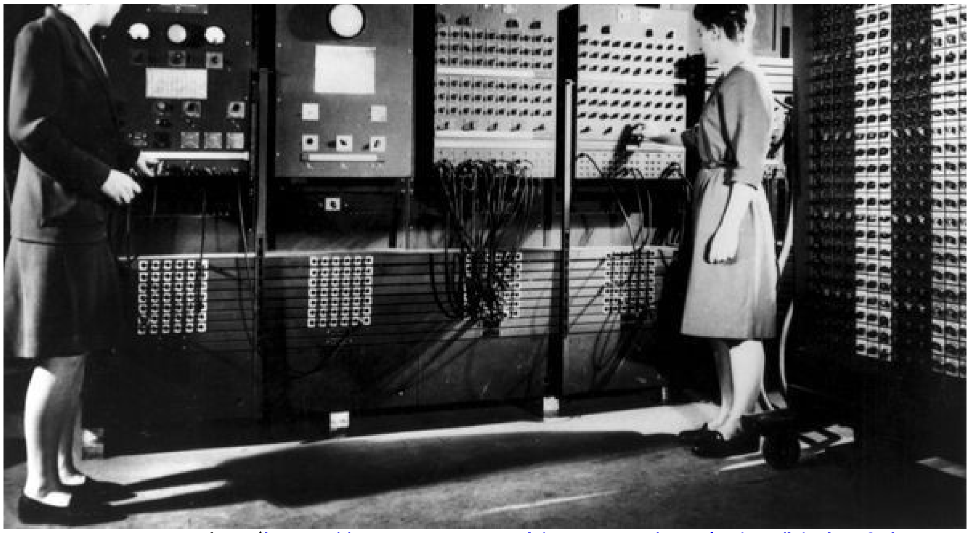
History

- The first computers?

Main frames?

$\boxed{\text{People?}}$



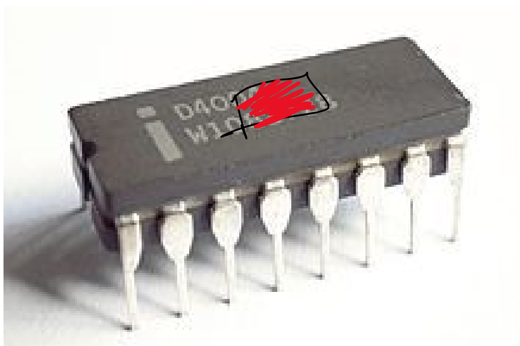


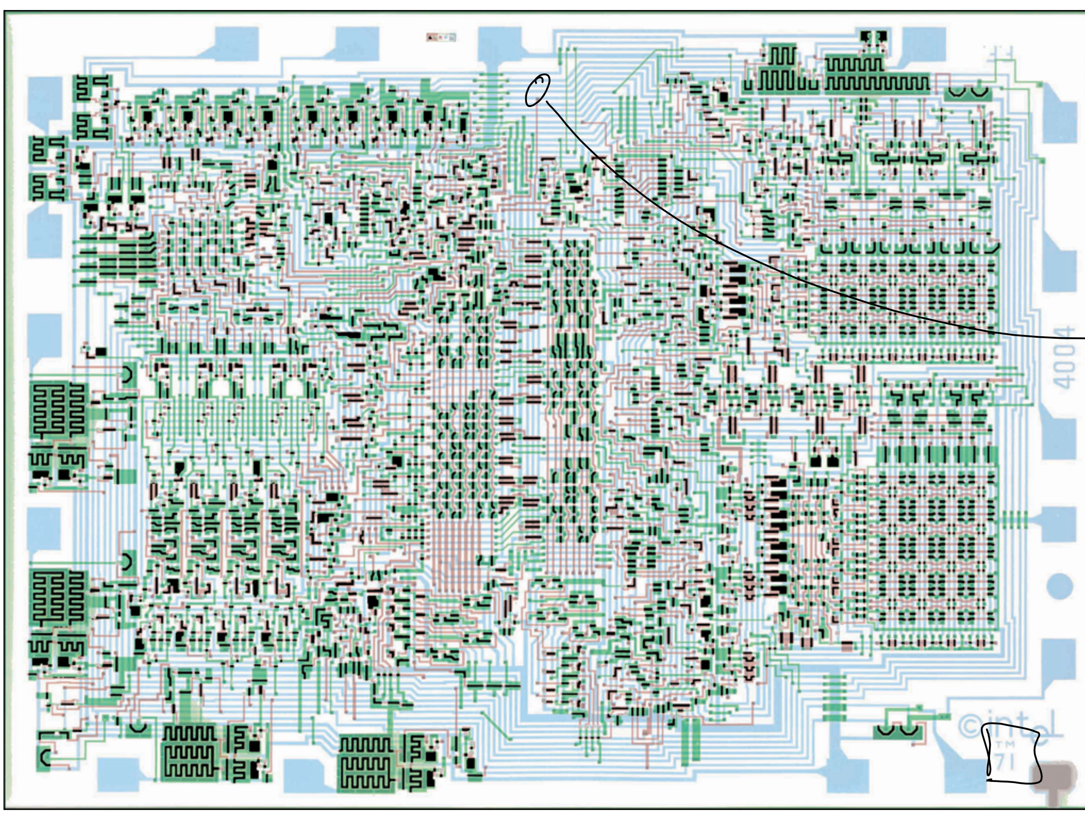
ENIAC: Vacuum tubes (https://www.computerhistory.org/revolution/birth-of-the-computer/4/78/317)

https://d34zi8nxray0rk.cloudfront.net/102695698-01-480.mp4

Intel 4004

Integrated circuits: CMOS transistors





4004

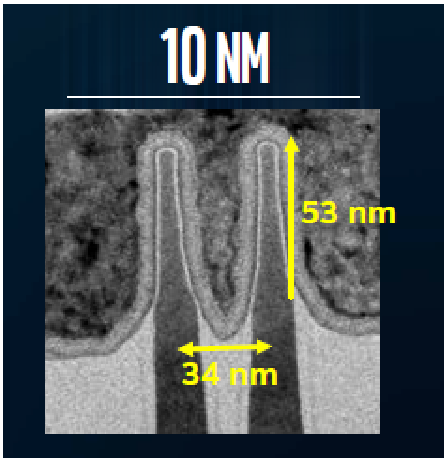
100,000 - 1M

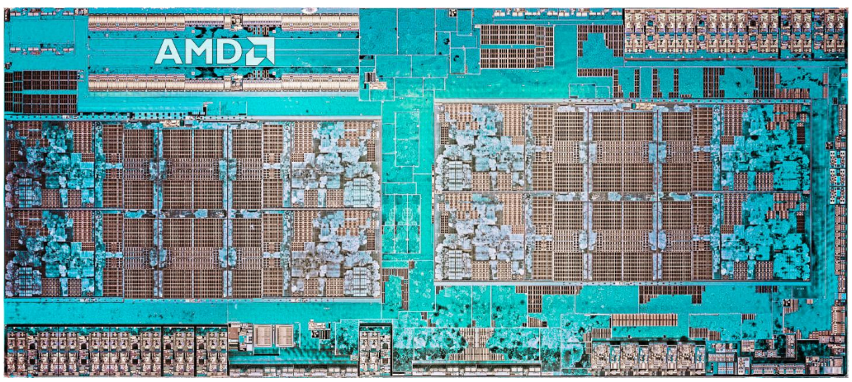
→ transistor

~2300

→ 10 μm

Today



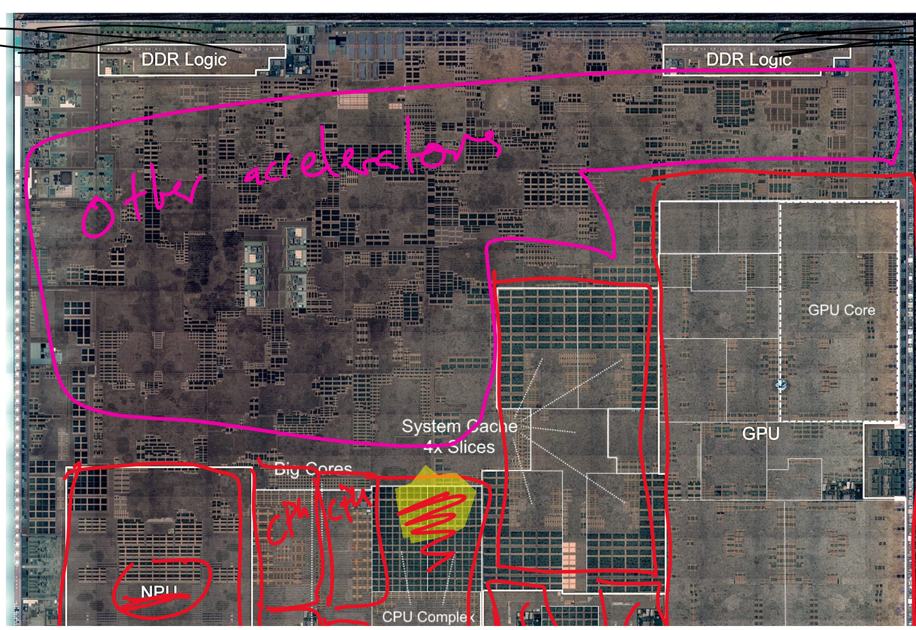


$\boxed{\text{5 billion}}$

$5 \cdot 10^9$

100 million fr

AMD Threadripper: Transistors?



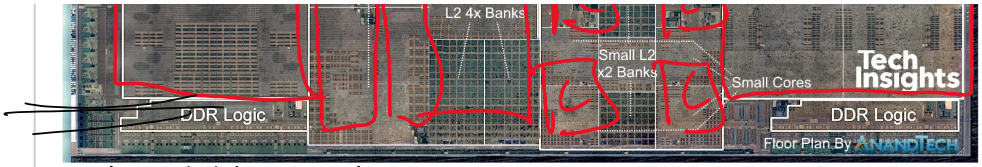
ASIC

A_1

2-3 billion

7 billion

7 nm



Apple A12 in iPhone X and XS
Transistors?

Moore's Law

Cramming More Components onto Integrated Circuits

GORDON E. MOORE, LIFE FELLOW, IEEE

With unit cost falling as the number of components per circuit rises, by 1975 economics may dictate squeezing as many as 65 000 components on a single silicon chip.

The future of integrated electronics is the future of electronics itself. The advantages of integration will bring about a proliferation of electronics, pushing this science into many new areas.

Integrated circuits will lead to such wonders as home computers—or at least terminals connected to a central computer—automatic controls for automobiles, and personal portable communications equipment. The electronic wristwatch needs only a display to be feasible today.

But the biggest potential lies in the production of large systems. In telephone communications, integrated circuits

Each approach evolved rapidly and converged so that each borrowed techniques from another. Many researchers believe the way of the future to be a combination of the various approaches.

The advocates of semiconductor integrated circuitry are already using the improved characteristics of thin-film resistors by applying such films directly to an active semiconductor substrate. Those advocating a technology based upon films are developing sophisticated techniques for the attachment of active semiconductor devices to the passive film arrays.

Both approaches have worked well and are being used in equipment today.

What is Moore's Law?

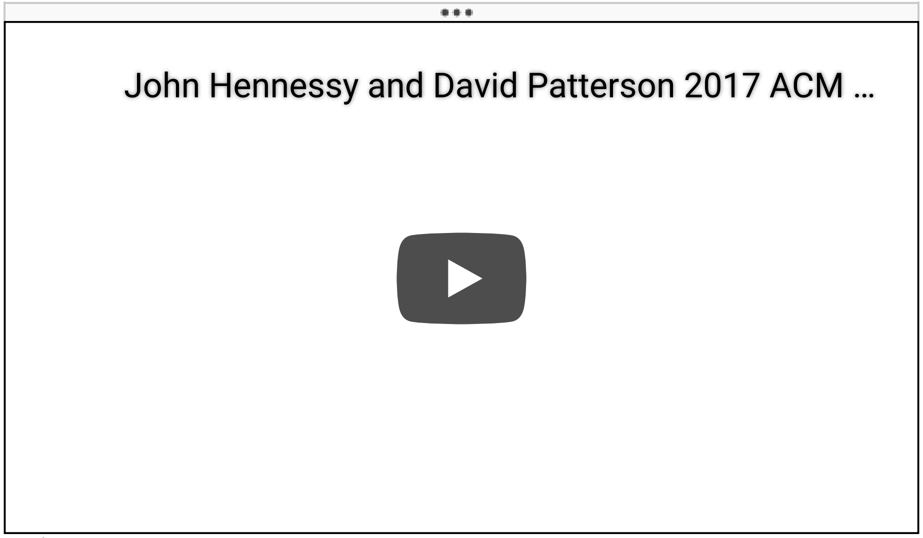
The Driver behind Moore's Law: Dennard Scaling

Table 1
Scaling Results for Circuit Performance

Device or Circuit Parameter	Scaling Factor
Device dimension t_{ox}, L, W	$1/\kappa$
Doping concentration N_a	κ
Voltage V	$1/\kappa$
Current I	$1/\kappa$
Capacitance $\epsilon A/t$	$1/\kappa$
Delay time/circuit VC/I	$1/\kappa$
Power dissipation/circuit VI	$1/\kappa^2$
Power density VI/A	1

What happens when Moore's Law slows???

[John Hennessy and David Patterson 2017 ACM A.M. Turing Award Lecture]



Turing Lecture 36:30