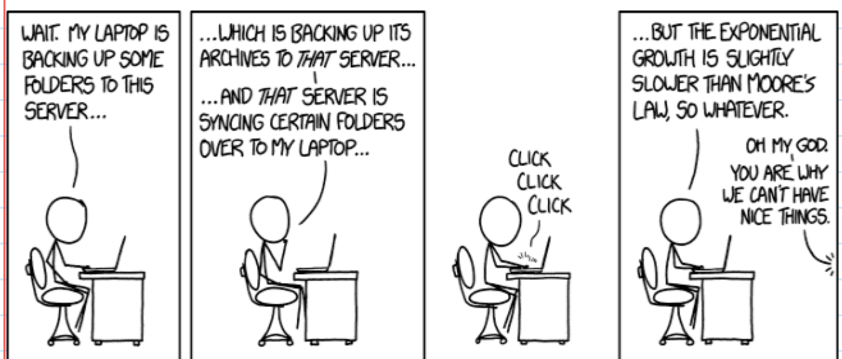
Lecture 2: Technology

Thursday, January 11, 2018 3:35 PM

Outline

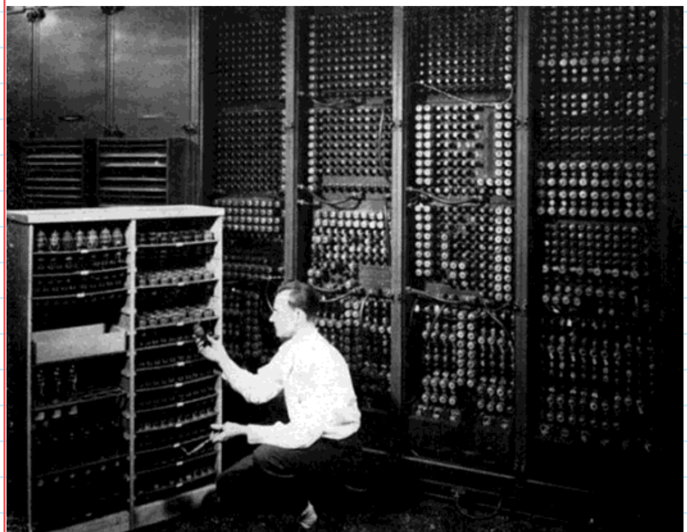
- History
- Moore's Law & Dennard Scaling
- Energy/Power of CMOS devices
- Technology trends
  - Transistor
  - Integration
- Latency vs bandwidth



History

What did the first computers look like?

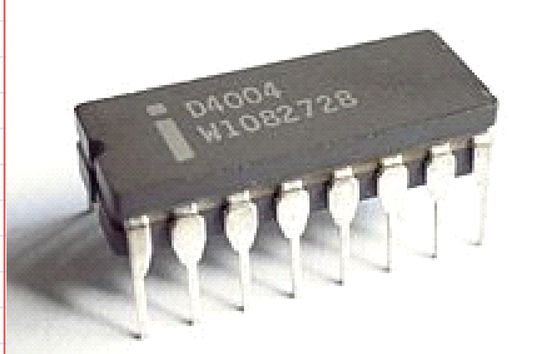
Technological change: Electronic computers



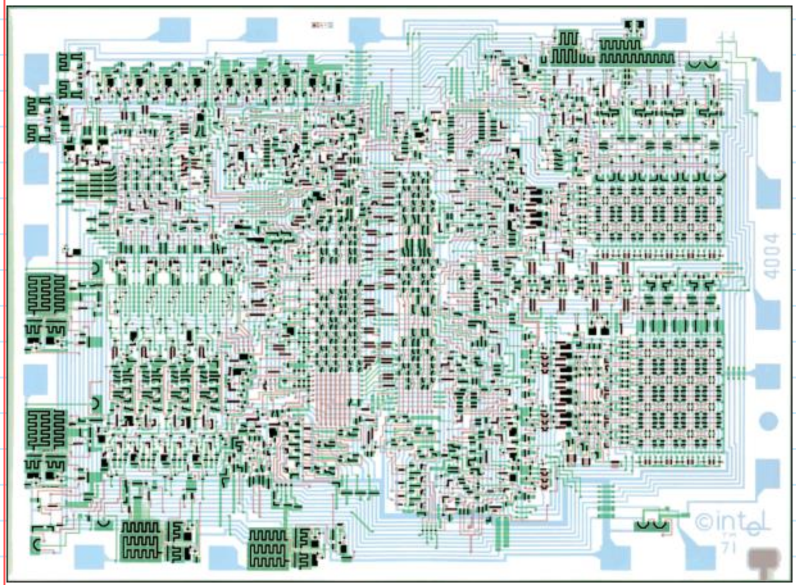
ENIAC: Vacuum tubes

TRADIC: Transistors

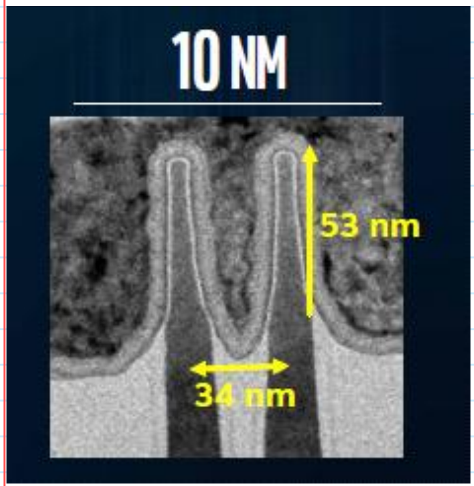
Intel 4004

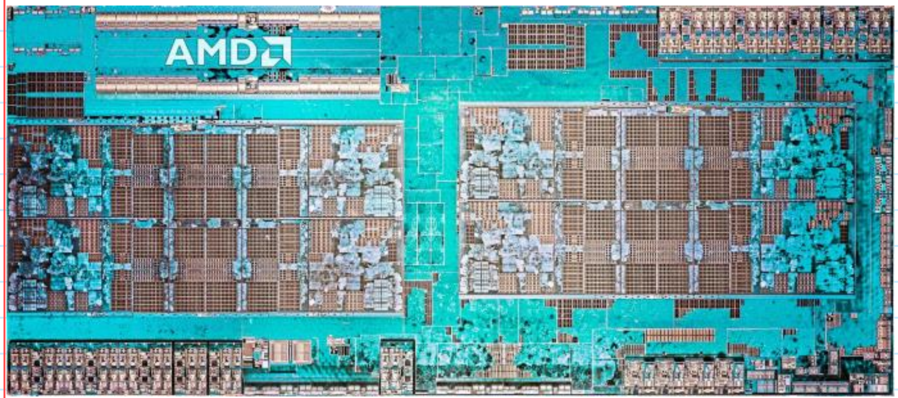


Transistors?

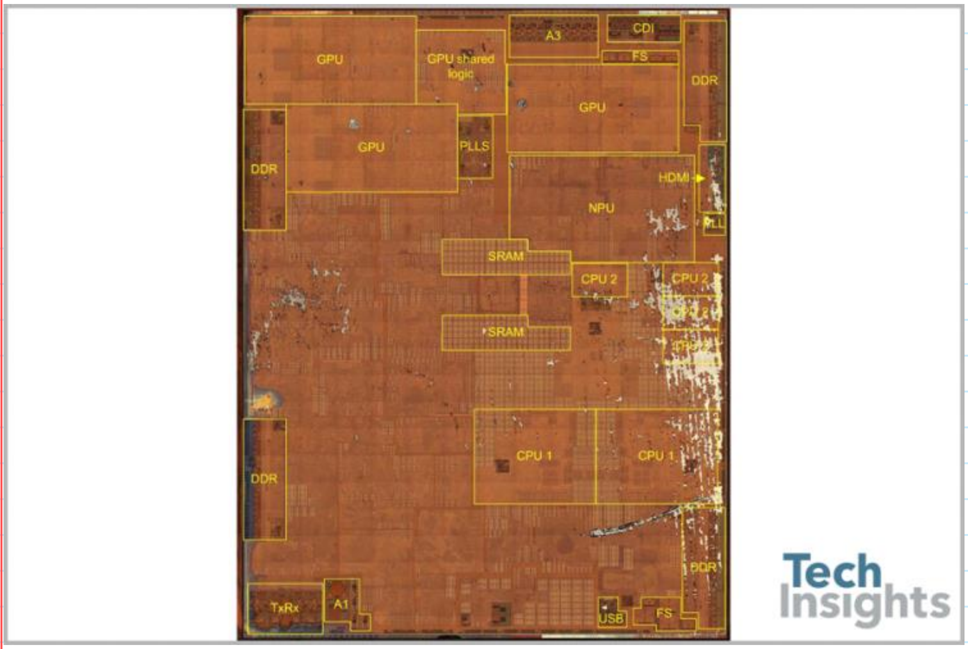


Today





AMD Threadripper
Transistors?



Apple A11 in the iPhone 8 & X
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?

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

Energy and power of CMOS

How does power and energy relate?

Energy =

Static energy:

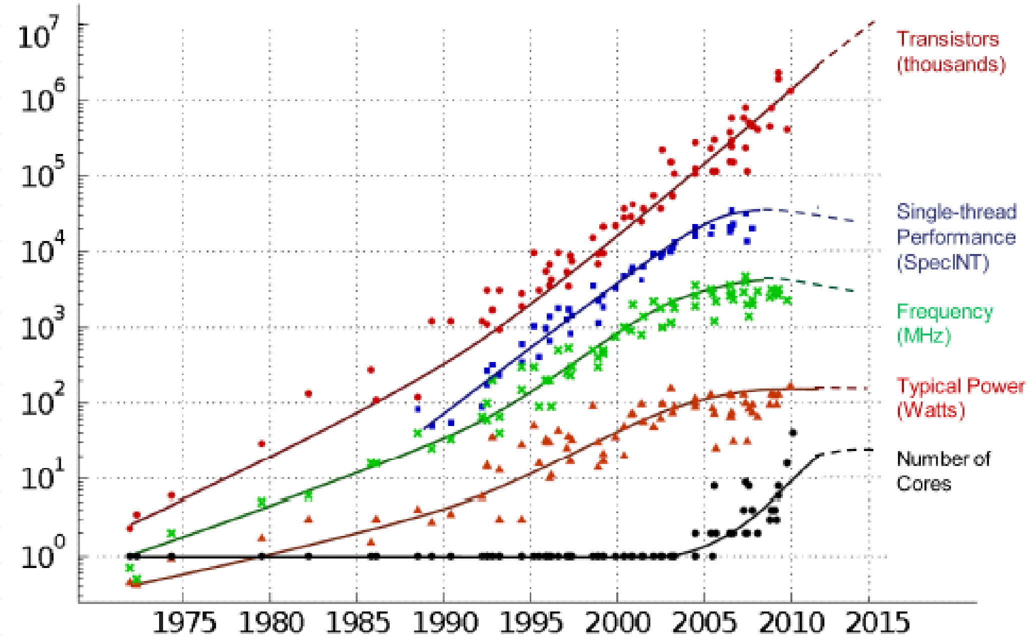
Dynamic energy:

Power =

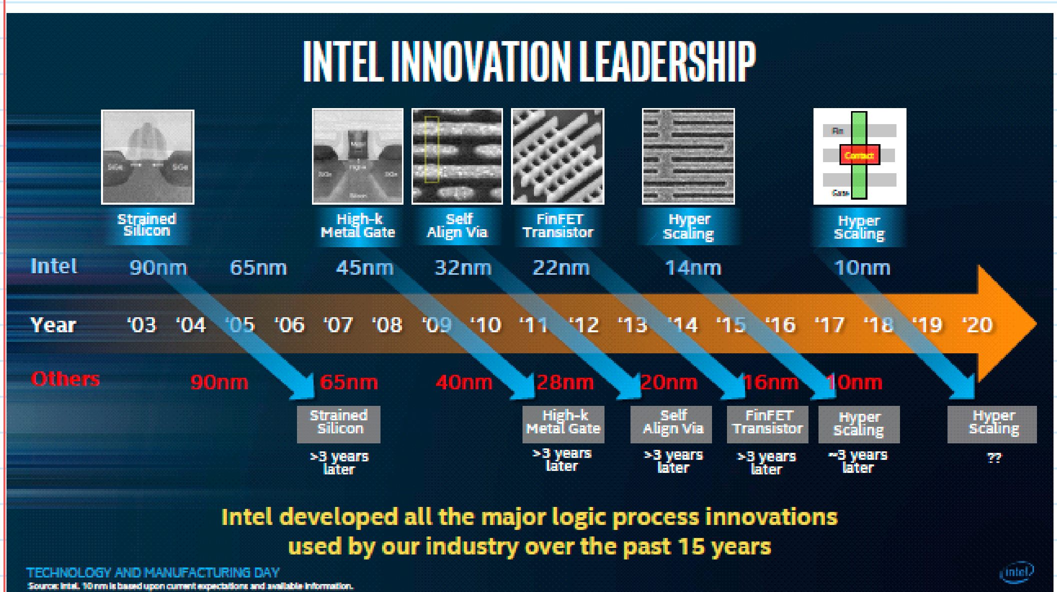
What is the most effective way to reduce (dynamic) power?

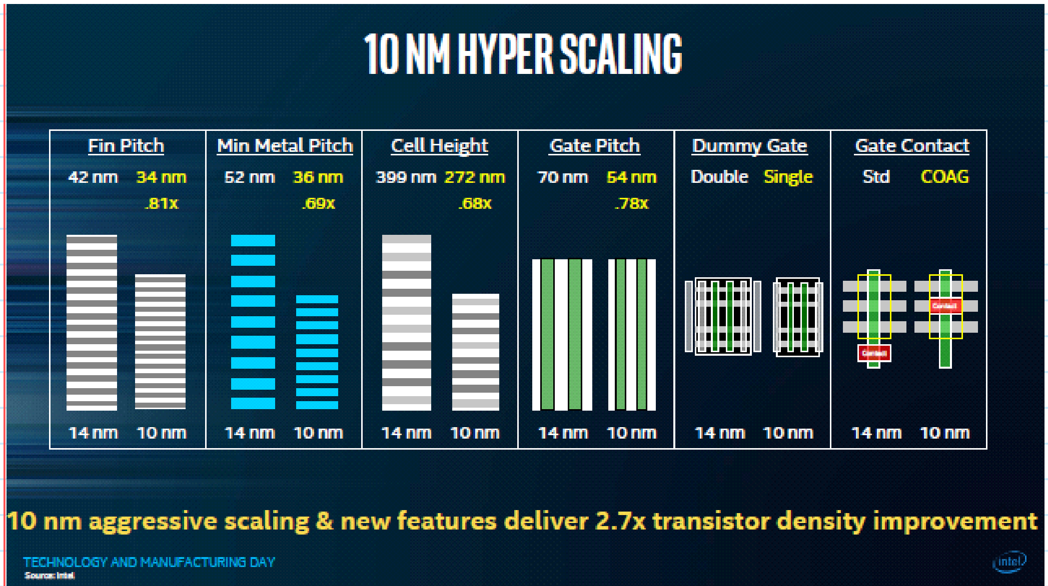
Trends

35 Years of Microprocessor Trend Data



Slides from Intel



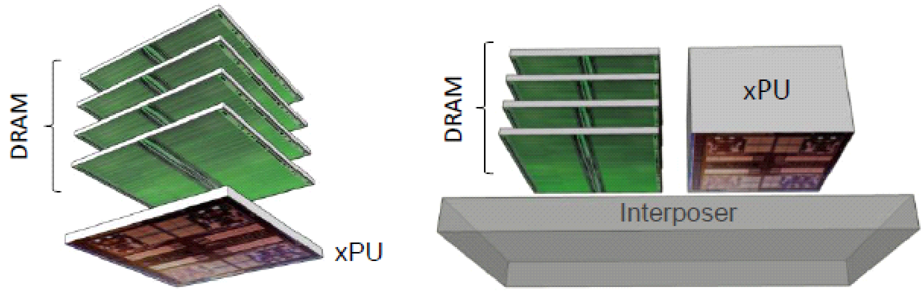


Other trends

DIE STACKING IS IDEAL FOR INTEGRATION

AMD

- All they do is reduce metal interconnect by improving proximity of disparate technologies

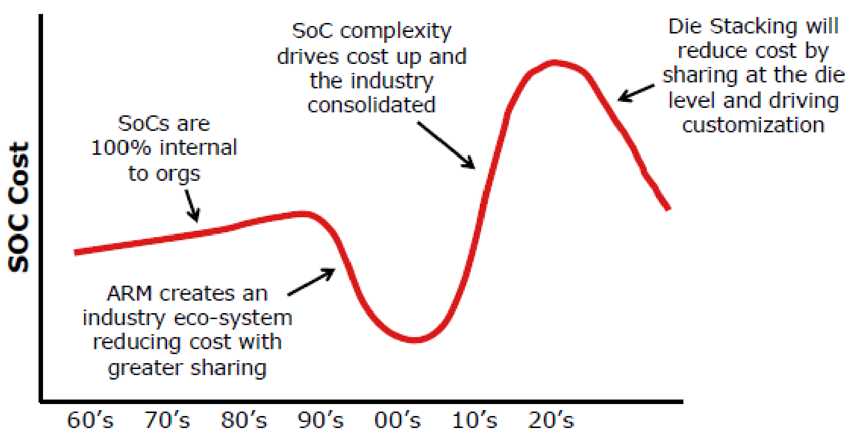


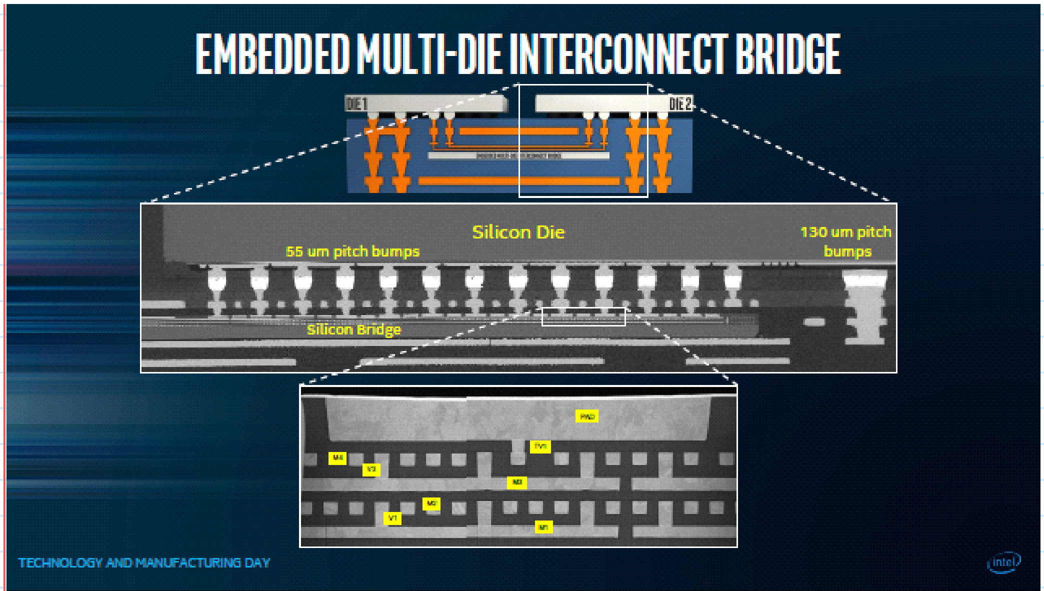
VERTICAL STACKING (3D)

INTERPOSER STACKING (2.5D)

AS ALWAYS COST WILL DRIVE THE NEXT EVOLUTION OF SOCS

AMD





Latency vs bandwidth: Moving data around

[Grace Hopper - Nanoseconds](https://youtu.be/JEpsKnWZrJ8)
SeHouMusic

https://youtu.be/JEpsKnWZrJ8

Trends

Bandwidth:

Latency:

Little's Law: