Moore’s Law, not anymore

What prevents it from continuing to be true

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What is Moore’s law?

It is an observation based law that states that the number of transistors in a dense integrated circuit are doubled at about every two years. This law is a projection of a historical trend. Moore’s law is not a traditional physical legality but linked to gains from experience in production.
Moore’s prediction held since 1975 and became as a known “law”.

There is a general argument on whether it is still applicable for modern circuits or as some states it is not applicable since 2010.

There are several obstacles that results in that Moore’s law is not or not fully applicable anymore and the trends are leaning towards instead of increasing the computing capacity of one component is to have multiple of them (e.g. multiple cores in a CPU, multiple CPUs on a motherboard, etc.).

Obstacles

1. Parasitic resistance

The parasitic resistance is a real limit for scaling. Until now the parasitic resistance and capacitance was considered as negligible for scaling however it has changed as the spacing between the transistors are decreasing.
The spacing between neighbouring devices decreasing to tens of nanometers since the source, drain and contact ize need to be scaled to support the increased density in the absence of gate length scaling.
Generally until now the parasitics did not matter since they were much smaller than the channel resistance and capacitance. Nowadays the parasitic resistance and capacitance are now becoming comparable and are on course to becoming even larger than the intrinsic device resistance and capacitance.

Current researches are focusing on new channel materials and very high mobility to overcome this barrier.

2. Electrostatics fine tuning of transistors

This obstacle is related to “Dennard Scaling”. It sais the voltage should scale with transistor size, it will keep the power consumption and temperature low.
The main problem with it is that the voltage can not scale all the way down, following the transistor size as:

- It must stay above a certain threshold voltage.
- Noise problems may occur.

It also did not consider power leakage.

3. Power consumption

The real problem regarding the power consumption is the failure of Dennard scaling, an observation that as transistors get smaller and circuits become faster a chip’s power consumption remains the same.
Increased power consumption is a straightforward result of the increased transistor density that could be somewhat controlled by size reduction until a certain limit.
“Transistors get hot because they use electrons, subatomic particles that carry an electric charge, to perform calculations and transfer information. As electrons flow, they bump into atoms and — just like rubbing two hands together — give off heat.” (Allan McDonald)
To overcome this barrier scientists are hunting for new materials where electrons could essentially slide in a group with minimalized friction.

4. Thermal limitations

Thermal limitations are closely related to power consumption and chip sizing.
As it was highlighted above as electrons flow they bump into atoms and generate heat.
When you make a processor smaller the more tightly packed electrons will heat up the chip so much so without proper cooling most powerful chips of today would simply melt down.

5. Cost efficiency

Moore’s law states that the number of transistors on a microchip doubles every two years while the cost of the computers is halved, it means that for an increasing computing capacity we will pay less and less.
As it can be clear by the other items, it is not the situation anymore as the transistor density increasement faces multiple physical problems and scientists are in a hunt for new materials to overcome some of those (e.g. to solve the heat problem). It means that as the microchip size decreasement is struggling the process is slowed down and manufacturing costs are tend to remain or increase.

6. Transistor size

Moore himself has stated in 2005. April 13th that soon a size limit will be faced in the transistor manufacturing industry, that atomic size will be reached soon that is a barrier of proceeding further with size reduction. This limit is predicted to be reached in “10-20 years”.

Bibliography

Parasitic resistance
https://www.sciencedirect.com/science/article/pii/S1369702106715395
General thoughts
https://open.lib.umn.edu/informationsystems/chapter/5-2-the-death-of-moores-law/
Moore’s law
https://www.investopedia.com/terms/m/mooreslaw.asp
Moore’s law (hungarian)
https://hu.wikipedia.org/wiki/Moore-t%C3%B6rv%C3%A9ny
The Death of Moore’s Law?
https://open.lib.umn.edu/informationsystems/chapter/5-2-the-death-of-moores-law/