# Moore’s law and its limitations

“Moore’s law” is actually not a physical law but a mere observation that *transistor density used to double every two years*. Since smaller transistors switch faster this is equivalent to an increase in CPU clock frequency.

This law stopped to be valid a few years ago. The reason is often referred to as “Power Wall”:

A higher density of transistors leads to a higher power consumption, which in turn leads to a higher temperature.

On the one hand, power consumption is a concern, especially in battery-powered mobile devices. On the other hand, the higher temperature, which ultimately might lead to the transistors melting, is the more pressing problem. Cooling with fans (or water but certainly not in mobile devices, see above) can only help up to a certain level.

The dynamic power can be calculated as follows:

P = a \* C \* F \* V^2,

where a is the percentage of switching, C the capacitance (which is related to the transistor size), F the frequency, and V the voltage swing.

Since there is a quadratic dependency on V, reducing the voltage swing is the first point to consider.

Here the Dennard Scaling comes into play which says that voltage swing should scale with transistor size. However, voltage cannot go too low for the following reasons:

* It must stay above a threshold voltage
* Noise becomes problematic at low voltages.

In addition, leakage power becomes a problem in denser system.

In conclusion, since transistor densities cannot increase significantly any more, multi-core systems and software that makes use of it in an appropriate way becomes the way to go.