Moore's Law

Moore's Law defines that the number of transistors doubles every 2 years. It is an observation made after noticing emerging trends in chip manufacturing.

Why Moore's Law is no longer applicable

However, it seems that the law has reached its physical limits in our current day. The processor's clock rate is no longer going up as much as it used to be. We are only able to increase the density of the chip as much as our ability to dissipate the generated heat. This is a result of the following properties:

Power Wall

Power Wall describes the limit in the number of transistors which can put into a chip due to the increased temperature. The increase in the number of transistors that we can put on a chip will increase the density, in turn results in higher temperature. Air cooling techniques such as using fans, heat sink, liquid cooling etc are employed, their effects are ultimately limited as we try to increase the power.

Dynamic Power

The generic equation of power (P) is given by **P = A * CFV^2** where,

- A is the percent of time switching — transistors consume power (called dynamic power) when they switch (from 0 to 1 and vice versa)
- C is the capacitance — related to the size of the transistor
- F is the clock frequency —how fast the device work relates to the clock frequency, but it's also increasing the power as we increase the clock frequency
- V is the voltage swing (from low to high) — we want to reduce this to save power, but is constrained by Dennard scaling

Voltage Scaling (Dennard Scaling)

In Dennard Scaling, it is said that voltage should scale with the transistor's size. As the transistors becomes smaller, we will be able to achieve higher density on our chip, in turn also like to scale down the overall voltage. However, we are unable to reduce the voltage due to physical constraints:

1. **Threshold Voltage and System Noise**: In order for transistors to switch, we will need to provide a voltage which is higher than the "threshold voltage", and reducing the amount of voltage will result in the reduction of the transistor's noise tolerance.

   This is important as voltage noise is present in every system. Transistors needs to have a threshold that is higher than the voltage noise so as to tolerate them in the event of a voltage noise. If we reduce the voltage threshold, the transistor won't be able to accurately judge if it is supposed to perform a switch.

2. **Leakage in Power**: As described in Power Wall, the increase in density of the transistors means that the distance (and insulation) between each transistor on the chip reduces. This results in the leakage of power due to insufficient insulation.