Moore's Law predicts that transistor density would double every two years. This level of transistor density growth has historically led to exponential growth in processing speeds. This was sustainable in the early day of processors as transistors were relatively huge and took up lots of space on circuit boards. In the modern era, starting around the turn of the century, clock speeds have not been able to keep pace with Moore's law.

The primary reasons for the decrease in the growth in transistor density are **heat and power**. In short, as **we increase transistor density, then we increase power consumption**. **As we increase power compsumption, we also increase the heat produced**. If we were to continue cramming more transistors into CPUs, then **we would hit the limits of air cooling and literally have chips melting.**

There is a concept called Dennard Scaling that contributes to Moore's Law working historically. Dennard Scaling means that as transistors get small they need less voltage and current, so power consumption relative to physical area stays constant. There is a formula ($P = \alpha * CFV^2$) that equates power consumption to a relationship between time switching (α), capacitor size(C), clock frequency (F), and square of voltage swing (V^2).

In the past, the reason Dennard Scallng worked was that while increases in clock frequency and time switching increase power, there were offsetting decreases due to capacitor size and most importantly voltage decreases. Overall this **Dennard voltage scaling is what keep overall power consumption low** as CPUs get faster.

The reason Dennard Scaling (and Moore's Law) have stopped, is that **voltage can not go too low. Due to noise, voltage scaling is limited to a transistor's voltage threshold**, below which it becomes impossible to tell the difference between "ones" and "zeros". As CPU circuit get smaller and smaller, there is **less insulation to stop power/heat leakage, which can not be prevented by Dennard voltage scaling.**

As Dennard Scaling stops, so ends Moore's law, meaning that **clock speeds can't significantly grow**, leaving hardware engineers looking elsewhere to increase performace**.** The only additional way to add more processing speed is by **adding additional cores and/or CPUs**. Another factor in overall processing speed is the **von Neumann bottleneck, which is caused by slow memory**. This is remaining area in performance increases by **adding more processor memory/caches**.