**Defination**

Moore's Law refers that the number of transistors that can be packed into a given unit of space will double about every two years, which brings the cost of computers is halved. It states that we can expect the speed and capability of our computers to increase every couple of years, and we will pay less for them. In general Moore's Law defines that this growth is exponential.

**Physical limitations**:

1. Thermodynamic limits -

The thermodynamic entropy to change n memory cells within m states is ΔS=kBln(mn), where kB is the Boltzmann constant. From the second law of thermodynamics, ΔS=ΔQ/T, where ΔQ is the energy spent and T is the temperature. So the energy required to write information into one binary memory bit is Ebit= kBT ln2. These are not the limits, yet.

2. Inclusion of Quantum Tunneling -

The probability of thermionic injection of the electron over the barrier height is GT=exp(-Eb/kBT). The probability of tunneling through the barrier is GQ=exp(-2a√2mE /ħ). For the two states to be distinguishable, the limiting case is Gerror=GT+GQ-GTGQ=0.5. Solving, we get Ebmin = kBT ln2 + (ħ ln2)2/(8ma2). The power for an area A having n devices operating at a frequency f is Pmax =f (n/A) [kBT ln2+(ħ ln2)2/(8ma2)].

3. Thermal limits -

How much we can allow the power to rise depends on how much rise in temperature the chip can stand (typically upto 400 °K) and on how fast we can remove the heat from the chip. Newton's Law of Cooling governs heat removal as Q = H(TDev - Tsink). H is the heat transfer coefficient, which is determined by the material constants like specific heat, viscosity, thermal conductivity, heat capacity, etc., apart from the geometry of the cooling structure.

4. Compton wavelength -

The Compton wavelength =ℎ/(~ 0.00243 nm for m = 9.1x10-31 kg) is the characteristic dimension of an electron, which has been proposed as a fundamental absolute limit of the size of an electronic device. At these length scales, there is a run-away-like divergence in power and Ebit, as apparent from Fig. 2. The reader is encouraged to plug in this length scale into the equations presented here (and into Fig. 2) to estimate power and Ebit and decide if it is sensible to even approach this limit.

5. Practical aspects -

Power consumption and speed are limited fundamentally by the devices, but practically by the electrical parasites, interconnects and chip architecture. This is the reason for the clock speed to have saturated at about 3 GHz for today's processors. All alternative ideas, like optical interconnects and more would see their limit in the domain conversion, which is limited by thermodynamics discussed here. The "2" in kBT ln2 can be made higher to, say, m, but that only pushes the limits by a factor of ln(m)/ln2.

