Abstract:

In contemplating the headlong rush toward miniaturization represented by Moore's Law, it is tempting to think only of the progression toward molecular sized components. There is a second aspect of Moore's Law that is sometimes overlooked. Because of miniaturization, the energy efficiency of information processing steadily improves. We anticipate that the energy required to process a single bit of information will eventually become as tiny as 1 electron volt per function, truly indeed a molecular sized energy. Inevitably, most logic functions including storage, readout, and other logical manipulations, will eventually be that efficient.

However there is one information-processing-function that bucks this trend. That is communication, especially over short distances. Our best projections, of improvements in the short distance communication function, show that it will still require hundreds of thousands of electron volts just to move one bit of information the tiny distance of only 10 micrometers. Why this energy per bit discrepancy for communications? It is caused by the difference in voltage scale between the wires and the transistor switches. Transistors are thermally activated, leading to a required voltage $\gg kT/q$. Wires are long, and they have a low impedance, allowing them to operate efficiently even at ~1 millivolt.

The challenge then is to replace transistors with a new low-voltage switch that is better matched to the wires. I will present some of the technical options for such a new switch, which are being explored by the new NSF Science & Technology Center for Energy Efficient Electronics Science.

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