Review for “Implications of historical trends in the electrical efficiency of Computing”

Summary:

In the given paper titled “Implications of historical trends in the electrical efficiency of Computing”, the author discussed some trends regarding improvements in energy efficiency, computer technology, and computation during the last few decades. This investigation starts from the advent of Electronic Numerical Integrator and Computer (ENIAC) back in 1946, which was the first computing machine with no moving parts and used electrical pulses for its logical operations, until the publication of this paper. He started with terming Moore’s law as an “empirical observation” rather than a law. According to which, a doubling of the number of transistors existing on chips will happen in almost every two years. Making Moore’s law as the basis of his investigation, he went on to investigate a few other trends that took place in the history of the evolution of computers. Another popular conclusion from Moore’s law is that after every 18 months the computing performance will be doubled, but turns out Moore has never said it. To make computers better, novel inventions and methods were key for the researchers. These inventions and methods made a significant improvement to the computation speed and efficiency of power consumption. To show long-term trends on electrical efficiency he compiled all the data that was available to estimate computations per kilowatt-hour on figure 1 in the given paper. He considered computers that had full load computational capacity and direct active electrical power for each of the computer. He then divided the number of possible computations per hour by the number of Kwh power consumed by the machine to get the computations per kwh. In figure 2, he showed the historical trends in computations done per second per computer. In figure 3, he showed the number of calculations per kwh of electricity consumed. The author went on to discuss vacuum tubes, transistors, and microprocessors and how these inventions changed the efficiency of computing in many ways. According to an estimation made by physicist Richard Feynman, we can improve our efficiency of the amount of electricity needed for computing by a factor of 10^11. But according to the author the efficiency has been improved by only a factor of 4*10^4. So, according to the author, even if we do not consider opting for optical and quantum computing, we have a long way to go to reach these theoretical limits calculated by the great Richard Feynman. Researchers were motivated to reduce the power consumption for computers that use vacuum tubes. As it had some computational speed and reliability issues. Smaller tubes, lower capacitive loading, and lower current consumption helped increase the computation speed. However, for computers that had transistors and microprocessors had to go through a process where the physical dimensions of transistors were reduced. This resulted in a better power efficiency, computational speed and minimization of cost.

According to the author, the most important and long-lasting effect of the improvement of efficiency in computational performance and energy usage is that it gave us the world of mobile computers, laptops, smartphones etc. As battery technologies have not improved that much when we compared with the improvement in computational efficiency and energy usage. So, according to the author, we can credit the rise of mobile phones and laptops mostly to the

increase in efficiency of energy usage, computational performance, reduction of capacitive loading, reduced current flow and a reduction of the tube size.

3 Strengths:

1- The author had to collect huge amounts of data from many sources to draw all the figures that are there in the given paper. Sometimes those data were not exactly in the form that he wanted. So, he had to make some adjustments and had to do some assumptions on his part to calculate energy efficiency over a long period of time. This I think was a major contribution from the authors part to understand the history of the trends that happened in the industry.

2- Here in this paper, the author has clearly demonstrated the correlation between the increase in energy efficiency and the widespread use of mobile phones and laptops. Even though battery technologies did not improve that much, due to the increase in energy efficiency and computational performance that did not become a bottleneck issue for the growth of the whole industry.

3- The author has been able to successfully identify and investigate the changes in technology that had a pivotal role in the development and the emergence of mobile phones and laptops.

3 Weakness:

1- While discussing the improvement of PCs that are transistor-based, the author only mentions about physical size reduction of the of transistors. But other power-hungry components (like hard-drive, RAM, video card etc) also went through much changes themselves which contributed to an overall change in power efficiency. He did not mention or considered these changes while accounting for the overall change in power and calculation efficiency.

2- The author only considered the power consumption of a PC when it is running under a full load, but a PC runs under a full-load only a fraction of the time and uses far less electricity when running at normal load. So, the calculations that he did in that assumptions could be wrong and that can show us a wrong trend of the power efficiency.

3- Many efficient algorithms have been invented and implemented since 1942. Which can also have a dramatic effect on power and calculation efficiency of computers. But authors did not account for any of that in this paper.

Future works:

The author quoted Richard Feynman and asserted that we are still very far away to achieve the

theoretical limits of power efficiency. So there is a lot of work that needs to be done on that front.

As we are seeing a burgeoning market for mobile phones and laptops, we need better batteries for them. But chemical engineers have not been able to improve battery technologies that much through the years. Also, while drawing power and computational efficiency trends, future researchers should also consider the improvements that happened over the years in other CPU parts and logical algorithms that actually calculate things for us.