Beyond Silicon: Optical Computing

Muhammad Aurangzeb Ahmad

Almost all computers these days are silicon-based which ultimately rely on electrical signals for processing information and because of this reason there would always be an ultimate speed limit on these computers *i.e.,* the velocity of electrons. There is however a way around such a limit --- Optical Computing. At the maximum, the signals in today's computers can travel at ten percent the speed of light. Although most of the world is becoming 'wired with light,' photons still have to make it to your desktop. Using light for exchange of information within the central processing computer could greatly increase the speed of these processors. Instead of having electrons, moving in and out as carriers of information, optical computers use pulses of light that are reflected or refracted by light sensitive molecules. In case of Optical computers it is impossible to have a short circuit. This is so because beams of light can cross each other without causing any 'trouble' and precisely because of this reason Optical computers are parallel by nature. A parallel computer is a computer with several processors that breaks down a problem into smaller problems and different components of the computer solve the problem in lesser time than a conventional computer.

A microchip in an optical computer, called an Optochip, would be essentially three dimensional in contrast to two dimensional circuits used currently. Beams of light would be reflected or reflected over surfaces and occasionally intersecting each other but with no loss of information. Memory will be stored in the form of three dimensional representations. Such memory representation is called Holographic memory. Data communication over the internet has largely become optical or is in the process of being so. Instead of a single 'file' of electrons, several beams of light can be transmitted at the same time without any loss of information since 'noise' in optical channels is virtually non-existent. Earlier this year scientists from University of California in Santa Barbra described networking technologies that can transmit 160 Gigabytes per second, that's more than a million times faster than the fastest internet service in Pakistan.

There is one catch however, which is largely holding back the optical computing revolution, the size of optical computers. Although Dr. Frazier and Dr. Abdeldayem of Lucent technologies and their group developed an all optical logic gate circuits in 2000 that could process information at Terabyte rates (1 Terabyte = 1024 Gigabyte), but the size of all optical computers in still quite large as compared to the desktop computers in use today. For example the smallest all optical computer is the size of a small van. Since nobody would trade his or her desktop computer for a computer that can only be placed in the garage than on one's desk, optical computing still has a long way to go. The most promising application for the near term is in the field of modulators. Modulators are like bridges between the optical devices and electronic devices like Computers, Televisions or Radios.

The alternative approach is a hybrid optical-electrical microchip. The earliest analog hybrid was made in 1978. Since then research in this field has gradually been shifting from analog Optical Computing to digital Optical Computing. A breakthrough towards

inorganic (The compounds that do not contain Carbon) Optochips came in early 2002 when scientists at University of Trento in Italy successfully created silicon laser, a truly remarkable achievement, considering that this feat is proclaimed impossible in some textbooks! The organic compounds are chosen if they are more sensitive to light as compared to inorganic ones. These classes of compounds are many times faster than inorganic compounds. There is however a problem with this type of computing in the long run: Light possess the ultimate velocity of 299,792,458 m/s but electrons can only have one-tenth of the velocity without causing 'unwanted' effects.

Optical Computing also opens up avenues for real-time three dimensional object representation, such that it would be possible to converse, see and even 'feel' the presence of a person over a futuristic version of the phone as if he or she is sitting next to you. At the other end of the road are technologies that will enable a person not only to watch a movie but be 'in' the movie. However it will be many years before such technologies are realized. Optimistic estimates predict that Optical Computing could become mainstream around the year 2015. Looking beyond Optical computing, one can envision DNA computers that use DNA to encode information. Peering even further reveals the possibility of Quantum Computers which would be exponentially larger than any other machine ever devised my mankind.

Blue and red lasers reflecting off mirrors
Image Source: United States Department of Energy/Coherent Inc Laser Group.