The Electron Pipe, 8 July 1991
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This idea seemed a good one to me at the time, but it has never been implemented. The nearest we've got is to use carbon nanotubes as short distance interconnects on chips and even that worked in totally different ways. My old friend, the late Paul McIlroy, did a quick analysis of this and explained to me why it could never be done due to the problems caused by space-charge effects. But I wasn't convinced and still hope there may be some element of feasibility and worth in this idea:

Fibre Upgrade: The Electron Pipe?

Ian D Pearson

Introduction

At present, ordinary desktop computer speeds are of the order of MFLOPS, memory of the order of Mbytes and communication speeds of the order of Mbit/s, with long term storage typically 10s of MBytes. These ratios seem to be reasonably acceptable. Main networking speeds are substantially lower, but this is less tolerable.

If these ratios remain constant, telecommunications is in big trouble, because the limited bandwidth of fibre may become a major bottleneck within 20 years!

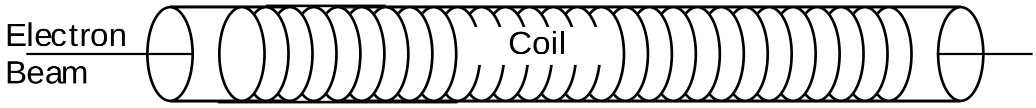
The Problem

Predictions for memory, longer terms storage, and computing speeds are already into the 'peta' range, i.e. 10^{15}. Timescales are quite long, in the 10 - 20 year range but still within sight. The current bandwidth estimates for fibre are lower than this by a factor of 10. If communication is not to become a major bottleneck (even assuming we can achieve these rates by then), new means of transmission need to be found.

The enormous advances in other fields will come largely by utilising effects down to atomic scale. IBM have already illustrated this by writing their logo in argon atoms. Communication using light is using wavelengths much greater than atomic scale, hence the bottleneck.

The Solution

Moving towards visible or ultraviolet would increase bandwidth but eventually, a way must be found to utilise other higher frequency entities. The obvious candidates are either gamma rays or 'elementary' particles such as electrons, protons and their relatives. Planck's Law shows that frequency is related to energy. A 1.3µm photon has a frequency of 2.3×10^{14}. By contrast 1MeV gives a frequency of 2.4×10^{20} and a factor of a million increase in bandwidth, assuming it can be used (much higher energies should be feasible if higher bandwidth is needed, state of the art 10Gev energies would give 10^{24}). An 'electron pipe' containing a beam of high energy electrons may therefore offer a longer term solution to the bandwidth bottleneck. Electrons are easily accelerated and contained and also reasonably well understood. The electron beam could be prevented form colliding with the pipe walls by strong magnetic fields which may become practical in the field through progress in superconductivity. Such a system may well be feasible. Certainly prospects of data rates of these orders are appealing.



Electron Pipe

Much work would be needed to study the feasibility of such communication systems. At first glance, they would seem to be more suited to high speed core network links, where the presumably high costs could be justified. Obvious problems exist which need to be studied, such as mechanisms for ultra high speed modulation and detection of the signals.

If they can be solved, the rewards are high. The optical ether idea suffers from bandwidth constraint problems. Adding factors of 10^{6-10} on top of this may make a difference!

Networking

The electron beam provides a communication channel which can be modulated by various mechanisms. Ideally, detection and modulation of the electron beam can be done non-destructively. In that case, radiation effects would be minimised and the cost of accelerators reduced. The signal could be read from the beam as it passed the node. Given the high bandwidth potential, data should not need to be destroyed on its travels, but free space could be modulated by the node in a drop and insert fashion. Thus the beam would not need to be absorbed and regenerated at each node, but should only need a single source.

It is interesting to speculate on the possible architecture of the network. Perhaps a tube resembling that for blown fibre may be possible, with a superconducting wire sheath to produce the holding field. Radii of curvature would depend on various factors such as beam energy and potential field strengths.