3D Microchips for More Powerful and Environmentally-Friendly Computers

10 December 2009

The world of IT pursues its race for performance. CMOSAIC could boost the computing performance of central processors by a factor 10 while consuming less energy. The IBM Research Laboratory has joined EPFL and ETH Zurich - the two Swiss Federal Institutes of Technology – in this project of national scope supported by the Swiss National Science Foundation (SNSF) via its Nano-Tera programme.

3D microprocessors cooled from the inside through channels as thin as a human hair filled with a liquid coolant. Such is the solution currently being developed by researchers from the EPFL (Ecole polytechnique fédérale de Lausanne, Switzerland) and its sister organisation ETH Zurich to boost the performance of future computers. The CMOSAIC project, under the leadership of John R. Thome in Lausanne, aims to develop processors 10 times more powerful with as many transistors per cubic centimetre as there are neurons in the same volume of a human brain – a functional density greater than ever before. IBM has just signed a partnership to join the adventure. Its Zurich-based lab will work together with the researchers from the Lausanne and Zurich Federal Institutes of Technology.

Not so long ago our computers had a single core which had to be boosted for performance – making each machine into a great central heating system. Beyond 85° C, however, electronic components become unstable. To overcome this physical limit, a solution was found with the multicore technology, where the same chip includes several processors which share tasks. Most of today's consumer electronics proudly boast a "dual core" or "quad core". However, in time the technology will come up against the same physical limits.

3D processors build on the idea of multicores. However, the cores are stacked vertically rather than placed side-by-side as in current processors. The advantage is that the entire surface of the core can be connected to the next layer, through 100 to 10,0000 connections per mm2. Shorter and more numerous, these minute interconnects should ensure that data transfer is 10 times faster, while reducing energy consumption and heat.

The Environment at Stake

The technological challenge is clear in terms of performance. But there is also an environmental stake. As John R. Thome, of the EPFL in Lausanne, explains: "In the United States, the industry's data centres already consume as much as 2% of available electricity. As consumption doubles over a five-year period, the supercomputers of 2100 would theoretically use up the whole of the USA's electrical supply!".

Although 3D microprocessors will use up less energy and generate less heat, they will still warm up. This is why John R. Thome's team is in charge of developing a revolutionary cooling system. Channels with a 50-micron diameter are inserted between each core layer. These microchannels contain a cooling liquid, which exits the circuit in the form of vapour, is brought back to the liquid state by a condenser and finally pumped back into the processor.

Next year, a prototype of this cooling system will be implemented and tested under actual operating conditions – but without a processor.

CMOSAIC is mostly funded by the SNSF via its Nano-Tera programme dedicated to cutting-edge information technology. Six labs at EPFL, ETH Zurich and IBM also contribute to financing and are each investigating a specific aspect of the project, coordinated by John R. Thome of EPFL, on the shores of Lake Geneva.

It will take a few years until 3D microchips equip consumer electronics. The initial 3D microprocessors should be fitted on supercomputers by 2015, while the version with an integrated cooling system should go to market around 2020.

http://actualites.epfl.ch/presseinfo-com?id=843

Infographie EPFL

PDF-Illustrator avec calques, caractère de base Arial

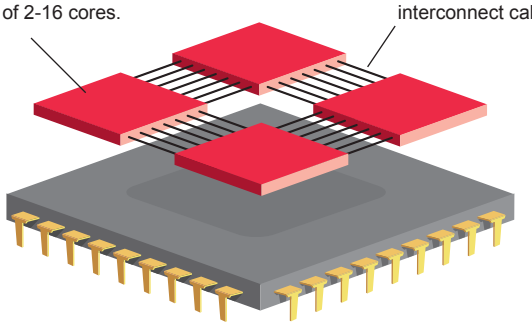
3D microprocessors for Future Computers

A new technology for stacking several layers of microprocesssors, which is being developed at EPFL in collaboration with ETHZ and IBM Research, could boost the performance of computer chips by a factor 10. The team estimates that the first 3D chips will be implemented in supercomputers by 2015 with a novel internal cooling system fully operational by 2020, for even further improvements.

Today's microchips

Cores - At present, processors in computers consist of 2-16 cores.

Cables - The cores are placed next to each other and communicate via interconnect cables.

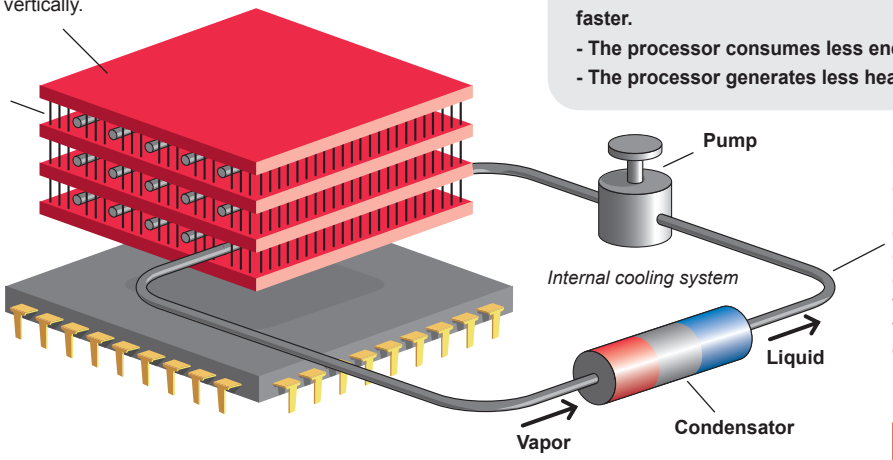


- The interconnect network consumes a lot of energy.
- The interconnnect network generates a significant amount of heat which could damage the chip.
- Heat and energy consumption limit the evolution of multicore technology.

Tomorrow's 3D microchips

Cores - The cores are no longer placed side-to-side but stacked vertically.

Cables



100 connections per mm2 link the cores over their entire surface. Advantages:
- Data transfer betweeen the cores is many times faster.
- The processor consumes less energy.
- The processor generates less heat.

Channels - As thin as a human hair (50 microns), the channnels filled with cooling water or evaporating refrigerant traversethe 3D microchip to maintain the optimal operating temperature.

Reference: EPFL, LTCM, John R. Thome
Infograph: Pascal Coderay, pascal@salut.ch

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE