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LAB TALK

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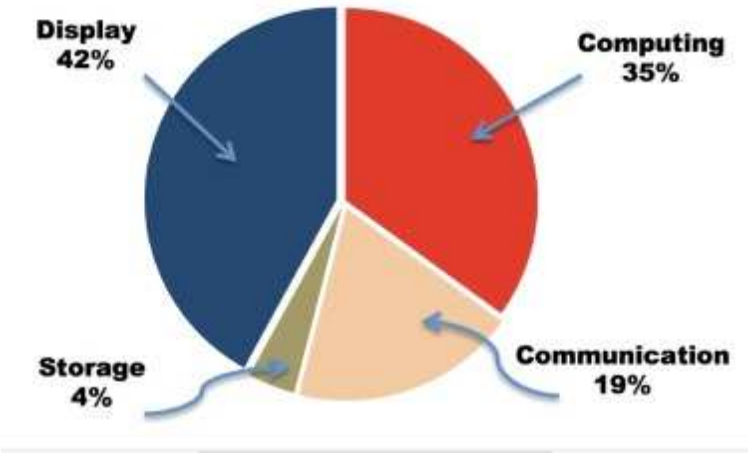
Can we build a computing device that works without any energy input?

Present day microprocessors consume too much energy. This is a serious limitation toward the realization of novel supercomputers – these would require a nuclear power plant to make them work. It's also a limitation toward the development of the 'internet-of-things' scenario. This is where small mobile devices process information and communicate autonomously, without disposable batteries. Reporting in *Nanotechnology* (http://iopscience.iop.org/0957-4484/26/22/222001/article), researchers consider what could be done.



(http://images.iop.org/objects/ntw/journal/14/5/8/figure1.jpg)

Division of energy consumption between the four main processing functions. (http://images.iop.org/objects/ntw/journal/14/5/8/figure1.jpg)

Electrical energy input by present day computers is converted into heat during information processing. The faster the information is processed the more heat is produced. If we want to push forward the development of future ICT systems we need to find a way to decrease the energy consumption per single operation.

Scaling down

In the last forty years the semiconductor industry has been driven by its ability to scale down the size of the CMOS-FET. This is the building block of present computing devices. It has also increased computing capability density up to a point where the power dissipated in heat during computation has become a serious limitation.

The grand challenge

The Nanoelectronics Research Initiative, in the US, is trying to overcome this limitation. Since 2004, it has launched a grand challenge to address the fundamental limits of the physics of switches. In Europe, the Future and Emerging Technology program has funded a set of projects with the aim of minimizing the energy consumption of computing.

Limits of consumption

In both cases the key aspects are associated with the ultimate limits of energy consumption during computation. Questions like 'what is the minimum energy required to do a calculation?' or 'how does the electrical energy transform into heat at micro and nanoscale?' need to be addressed. They also need to be answered if the energy dissipation has to be dropped, together with the introduction of novel nanodevices that substitute semiconductor transistors. Nanomagnets and nano-electromechanical systems seem to provide a promising test bench for zero-power ICT.

More information about the research can be found in the journal *Nanotechnology* **26 222001** (http://iopscience.iop.org/0957-4484/26/22/222001/article).

Further reading

Integrating planar memristors with CMOS circuits (Sept 2014) (http://nanotechweb.org/cws/article/lab/58594)
Memcapacitors could make our computers faster (Jun 2014) (http://nanotechweb.org/cws/article/lab/57674)

About the author

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Giovanni Carlotti is professor of condensed matter at the University of Perugia and the head of the GHOST group.