Abstract

State of the art ICT basic devices are dominated by power dissipated in heat. Presently the main effort is aimed at cooling down the heat produced during computation with specific attention to the charge transport on one hand and on the other hand on reducing the voltage operating levels up to the point of not compromising the error rate due to voltage fluctuations. In this scientific session we proposed to address the problem at a very fundamental level: what are the basic mechanisms behind the heat production? How can we take advantage of the fluctuations instead of avoiding them? These questions should convey the idea that the proposed approach is way beyond the state of the art. It is not simply an incremental progress toward the reduction of heat production in room temperature conductors or new technology beyond CMOS. It is a new, visionary approach that challenges the very basic foundation of thermodynamics.

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Keywords: power dissipation; noise; fluctuations; beyond CMOS; energy harvesting; zero power; chip cooling; thermodynamics

1. Introduction

This scientific session has the specific objective of promoting the emergence of a new community interested in ICT-Energy issues. Such issues can be usually summarized under two main headings: i) Power dissipation in IC circuits; ii) Noise limited computation performances. Clearly these represent two aspects of the very same fundamental physical topic called “energy dissipation”.

In this perspective an ICT device is a machine that inputs information and energy (under the form of work), processes information and outputs information and energy (mostly under the form of heat). Energy efficiency is usually defined as “the percentage of energy input to a device that is consumed in useful work and not wasted as useless heat”. However this definition does not apply when we deal with processes at nanoscale as in the next generation of ICT devices. The very basic mechanism behind energy dissipation requires a new definition when non-equilibrium processes involving only few degrees of freedom are considered: the dream of highly efficient devices has to deal with a rethinking of both energy and information dissipation.

On the other hand, future ICT will be largely affected by nanoscale devices that process information while transforming work in to heat and heat into work. Pioneering work developed by J. Von Neumann and by R. Landauer in the last century has shown that information processing is intimately related to energy management (“information is physical”).

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Energy efficiency in operating such devices is presently considered an objective of extremely high relevance. According to the SMART2020 study, the share of ICT on the worldwide energy consumption today is in the range of 2-5%. Given that the use of ICT will further increase and the overall energy consumption will hopefully decrease due to the help of ICT and other measures, it is expected that the share of ICT on the world wide energy consumption will grow in the future. Hence, it becomes more and more important to consider and improve the energy efficiency of ICT. On the short term, it will be an obvious and practical solution to exploit better the potential of technologies that already exist or are currently in the making. On the long term, new and disruptive ideas will be needed (Fig. 1).

2. A wider community

From this brief introduction it should clearly emerge that the topic itself asks for a wide community of scientists whose expertise runs from Solid State Physics to Statistical Thermodynamics, from IC-Architecture to the foundation of Information Theory, just to mention few fields interested by our approach. Thus the target audience is very wide and covers both researchers interested in fundamental and applied aspects of the ICT-energy connection as well as industry managers and strategic advisors interested in the future of ICT where energy issues are expected to play a major role. Finally the target audience includes also policy makers that are interested in a deeper understanding of the scientific and technological aspects of the energy-ICT relation. In fact, it is worth noticing that there are embryonic research efforts, distributed at European level, that are today barely visible.

The FET Proactive program “Toward Zero-Power ICT” (FP7-ICT-2009-4) has had the role of focussing attention on the topic and bringing to coalescence research branches that are developing independently in different communities and different countries. Four consortia that participated to this program have recently joint their efforts in a Coordinated Action activity (FP7-ICT-2009-6) called ZEROPOWER (Co-ordinating Research Efforts Towards Zero-Power ICT - Grant agreement no: 270005), in order to build a larger community interested in ICT-Energy related issues. The recent Expert Consultation “Disruptive Solutions for Energy Efficient ICT” held by the FET Proactive unit in Brussels on Feb. 8-9 2010 [1] has demonstrated that it is also the intension of the EC to keep focussing on these topics in view of the FP7 Proactive Research Challenges & topics for the 2011-2012 Work Programme [2] and specifically in Objective ICT-2011.9.8: FET Proactive: Minimising Energy Consumption of Computing to the Limit (MINECC”).

For these reasons, our scientific session brought together international experts interested in the realization of efficient low-power ICT devices, covering the following aspects:

- Minimization of energy dissipation and thermal management in present CMOS devices (B. Michel, IBM Zurich)
- Energy dissipation at nanoscale (E. Pop, Univ. Illinois)
- Energy efficiency definition and non-equilibrium phenomena (F. Marchesoni, Univ. Camerino)
- Enabling low power micro/nano-technologies for autonomous systems (Florin Udrea, Cambridge University on behalf of Adrian Ionescu, EPFL)

Slides from the presentations are available at: http://www.nanopwr.eu/node/173.
Acknowledgements

The author gratefully acknowledge financial support from the European Union (FPVII 2007-2013) under grant agreement n° 256959 NANOPOWER and grant agreement n° 270005 ZEROPOWER and Fondazione Cassa di Risparmio di Perugia (Bando a tema - Ricerca di Base 2009, Microgeneratori di energia di nuova concezione per l’alimentazione di dispositivi elettronici mobili).

References