Project title:	EXA2GREEN - Energy-aware sustainable computing on future technology – paving the road to exascale computing
In Brief	Improving energy efficiency in high performance computing

Introduction

EXA2GREEN aims at developing a new energy aware computing paradigm and programming methodology for exascale computing to reduce energy consumption and the resulting performance trade-off. The considered approach takes the aspects of energy efficiency into account at all simulation levels, from the kernel, numerical/combinatorial building blocks to the application level by means of dedicated mathematical models and adequate software engineering.

Main summary & conceptualism

In the second half of the 20th century, simulation has been established as the 'third pillar of scientific discovery', complementing theoretical analysis and experiment. The performance of High Performance Computing (HPC) hardware has since then increased rapidly, steadily driven by the ever-increasing demands for computing power in many areas of science. In 2008 the RoadRunner supercomputer was the first in breaking through the Petaflop barrier by delivering a performance of over 1 Petaflop/s = 10^15 floating point operations per second.

As the HPC community prepares for the upcoming Exascale age, it needs to face formidable challenges. The energy consumption of many HPC systems has reached a critical level, where the running costs for energy become equal to the acquisition costs for the hardware after only a few years. As of 2013, the most energy-efficient HPC systems deliver a performance of 2-3 Megaflops per Watt. An Exaflop system built using the same technology would require 300-500 Megawatts of power, which is for almost all HPC-sites untractable.

While it is widely recognized that advances in hardware design and manufacturing will lead to a significant increase of energy efficiency, it is less noticed that there is also much potential to reduce the energy consumption on the level of mathematical modeling and software engineering. This is the line of research and development pursued by the Exa2Green project. Its key aspect is that the issue of energy consumption and the resulting trade-off between the performance and the accuracy of the simulation will be taken into account in all simulation levels: from the kernel, numerical building blocks to the application level.

With different project partners from academia and industry, the consortium combines the competences and skills that are necessary to tackle the challenges related to energy-efficient high performance computing. The research is focused on the following topics:

- Design of tools for power monitoring and profiling.
- Development of new metrics for the quantitative analysis of the energy profile of algorithms.
- Implementation of energy-aware elementary kernels.
- Development of energy-efficient linear algebra libraries and linear solvers.
- Implementation of an energy-aware scheduling technology for HPC clusters.

- Optimization of the weather forecast software COSMO-ART for energy-efficiency in order to conduct a proof of concept for the methodologies and technologies developed in the Exa2Green project.

Exa2Green is a 3-year research project co-funded under the EU 7th Framework Program 'FET Proactive Initiative: Minimising Energy Consumption of Computing to the Limit'. FET (Future and Emerging Technologies) aims to go beyond the conventional boundaries of ICT and ventures into uncharted areas, often inspired by and in close collaboration with other scientific disciplines.

The partners of the project are Heidelberg University (project coordinator, Germany), ETH Zurich / CSCS (Switzerland), HPCA - Universitat Jaume I de Castellon (Spain), IBM Research Zurich (Switzerland), KIT - Institute for Meteorology and Climate Research (Germany), Steinbeis-Europa-Zentrum (Germany) and Universität Hamburg (Germany).

Key words:	Green computing, high performance computing, power wall, exascale computing, COSMO-ART

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