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Towards future supercomputing: EU project Exa2Green improves energy efficiency in high performance computing

The Exa2Green project is paving the road towards exascale supercomputing. Approaching the end of the project after three years of research, the team can show remarkable results.

Future exascale supercomputers will be capable of performing a quintillion, i.e. 10^{18} floating point operations per second – a work rate that equates the computing power of about one hundred of today's supercomputers. The availability of such immense computing power will allow for fundamental progress in answering complex scientific research questions, as they arise in environmental sciences, energy or economy. However, the path towards exascale computing involves numerous challenges, with a key one being power consumption. Using today's technologies, such supercomputers would consume the power of a small town. How to tackle this challenge and make exascale computing more power efficient? The Exa2Green project has taken up this challenge and developed new energy-aware computing paradigms for future exascale computing.

While it is widely recognised 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 algorithmic design and software engineering. This was the line of research and development pursued by the 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 basic algorithmic kernels, to energy-efficient solvers up to the level of large applications such as climate models.

Comprising an interdisciplinary research team of High Performance Computing (HPC) experts from Germany, Switzerland and Spain, the Exa2Green team focused on three main activities: first, developing tools for measuring the performance and energy consumption of computations; second, analysing existing, widely used computational kernels and developing new energy-efficient algorithms; and finally, optimising a compute-intensive climate model to achieve a considerable reduction of energy consumption in climate simulations.

"Current HPC platforms consume such a huge amount of energy that the further successful development and use of such systems will strongly depend on optimisation towards energy efficiency", explains Professor Vincent Heuveline, the coordinator of Exa2Green at the University of Heidelberg. To gain insight into the power consumption, Exa2Green developed a software tool to trace and analyse the power and energy consumption of parallel scientific applications. This enables scientists and technicians to identify sources of power inefficiency and to optimise the application code. Additionally, the researchers have designed ArduPower, a small, low-cost and accurate measurement device that can be used to investigate the power consumption of scientific applications of HPC infrastructures. Team members have also produced accurate models for the characterisation and time-power-energy prediction of several elementary computational kernels, the so-called computational dwarfs.

Within the project, the COSMO-ART weather forecast model has been utilised as an example of a computationally intensive application, whose energy profile is currently far from optimal. By means of the power-performance measurement framework developed, Exa2Green could investigate the energy footprint and performance profile of COSMO-ART on various HPC platforms. This allowed to identify energy-consumptive components. The expertise acquired within the project was then used to develop energy-aware implementations to replace some of the energy-intensive components. Amongst others, a mechanism was introduced, that reduces the power consumption during the idle periods inherent to task parallel executions, achieving significant energy savings. Finally, the project could endow the weather prediction community with an energy-efficient implementation of COSMO-ART that allows for higher resolution forecasts over longer periods, at reduced cost to the environment.

After three years of collaborative work, the achievements of the researchers are impressive. Exa2Green is confident that their work will not only pave the road towards future exascale computing, but also makes a valuable contribution to an energy-aware usage of today's computers: “Besides the evident intrinsic value of new energy-aware algorithms which are able to solve the same problem consuming less energy, this work is extremely important to develop a new holistic vision on energy-aware computing which comprises dedicated improvements in hardware and software design”, notes Professor Heuveline.

Exa2Green was a 3-year research project co-funded under the EU 7th Research Framework Programme “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 interdisciplinary project consortium comprises partners from the fields of HPC, computer science, mathematics, physics and engineering. The partners contribute with their specific competences in the collaboration to address the research topics. The partners of the project are University of Heidelberg (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).

For more information, please visit:
http://exa2green-project.eu

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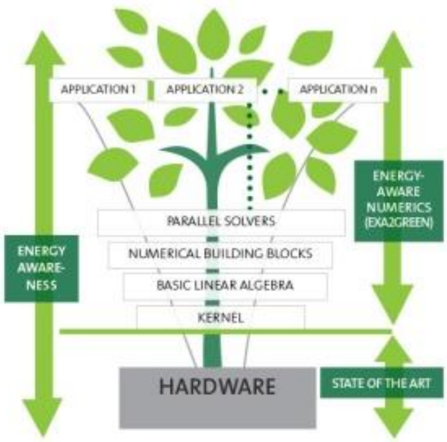

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