Exa2Green
energy-aware numerics

NEWSLETTER #6
October 2015

Dear Reader,

Welcome to the sixth and final issue of the Exa2Green newsletter. It is our pleasure to keep you up to date with the progress of our project and to make you aware of the news and activities around energy-efficient high performance computing.

After three years of intense research and collaboration, Exa2Green is now coming to an end. In this newsletter we look back on the results of our work.

We also report on recent activities and events of Exa2Green: the workshop at ISC 2015 in Frankfurt, the partner meetings in April and September 2015 and Exa2Green presentations at the 26th PARS Workshop in Potsdam, the PASC15 Conference in Zurich, the Euro-Par Vienna 2015 and at ParCo 2015 in Edinburgh (UK).

We hope that you will enjoy reading and we also kindly invite you to visit our website at www.exa2green.eu which will also keep you updated about all activities around the Exa2Green project.

Yours sincerely,

The Exa2Green consortium

SEVENTH FRAMEWORK PROGRAMME

CONTENT

Exa2Green ID

Title

Energy-Aware Sustainable Computing on Future Technology —Paving the Road to Exascale Computing

Programme

Seventh Framework Programme, Collaborative Project

Project No.

318793

Duration

01/11/2012-31/10/2015

Main objective

***Exa2Green** aims at developing a radically new energy-aware computing paradigm and programming methodology for exascale computing.*

Partner countries

Germany, Switzerland and Spain

EXA2GREEN CONSORTIUM

Exa2Green Project Partners:

Coordinator:
Engineering Mathematics and Computing Lab (EMCL)
Interdisciplinary Center for Scientific Computing (IWR)
Heidelberg University - Germany

High Performance Computing and Architectures Group
Universitat Jaume I de Castellon - Spain

IBM Research - Zurich - Switzerland

Institute for Meteorology and Climate Research
Karlsruhe Institute of Technology - Germany

Scientific Computing Group, Department of Informatics
Universität Hamburg - Germany

Steinbeis-Europa-Zentrum - Germany

Swiss Federal Institute of Technology Zurich
Swiss National Supercomputing Centre - Switzerland

PROJECT NEWS

Exa2Green comes to an end — Looking back at three successful years

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 Exa2Green, which took into account the issue of energy consumption and the resulting trade-off between the performance and the accuracy of the simulation 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.

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. 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. 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. The expertise acquired within the project was then used to develop energy-aware implementations to replace some of the energy-intensive components. 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.

Further information:
http://exa2green.eu/press.php

PAST EVENTS

Successful Exa2Green workshop at ISC 2015

Nearing the end of the Exa2Green project, various remarkable research results have been achieved. The **workshop "Power & Energy-Aware High Performance Computing on Emerging Technology"**, which took place on 16th July in the frame of the ISC High Performance 2015 in Frankfurt (Germany) was the possibility for the project partners to present these results, embedded in a broader programme with keynote speakers on the topic.

The workshop focused on new energy-aware computing paradigms and programming methodologies to address the problem of prohibitive power consumption by current hardware when extrapolating to exascale machines. It brought together scientists and engineers from academia and industry with interests in energy-efficient computing.

Workshop topics included:

- Tools for advanced power consumption monitoring and profiling.
- New multi-objective metrics for quantitative assessment and analysis of the energy profile of algorithms.
- Smart algorithms using energy-efficient software models.
- Power-aware implementations of numerical methods for high performance clusters.
- Performance/energy optimization in applications, showcases, proof of concepts.

Keynote speakers of the event were:

- Axel Auweter (Leibniz Supercomputing Centre)
- Prof. Dr. Kirk W. Cameron (Department of Computer Science, College of Engineering, Virginia Tech)
- Prof. Dr. Dimitrios S. Nikolopoulos (School of Electronics, Electrical Engineering and Computer Science, Queen's University of Belfast)
- Prof. Dr. Rudolf Lohner (Steinbuch Center for Computing, Karlsruhe Institute of Technology)
- Dr. Dominik Brunner (Empa)

Further information can be found on the event's website:
http://www.isc-events.com/isc15_ap/sessiondetails.htm?t=session&o=219&a=select

PAST EVENTS

Exa2Green M30 Partner Meeting in Hamburg

On 27th and 28th April 2015 the Exa2Green project partners met in Hamburg (Germany) for the Month 30 project meeting. At the premises of partner University of Hamburg the partners presented and discussed the main developments of the previous six months.

All work package leaders reported of a continuously good performance and further promising results. The quality of Exa2Green's work was also proved through the numerous reported milestones, the participation at conferences and workshops as well as publications.

The meeting was rounded by a visit to the German Climate Computing Centre‘s server room, guided by the centre's director Prof. Dr. Thomas Ludwig.

Exa2Green Final Meeting in Stuttgart

On 29th September 2015 the Exa2Green partners met for the project's final meeting. During the intense one day meeting the partners looked back on the three years of successful collaboration, discussed the project's achievements and planned the activities of the last project month.

PAST EVENTS

Exa2Green at 26th PARS Workshop in Potsdam (Germany)

The section "Parallel Algorithms, Computer Architectures and System Software (PARS)" is a common section of German Informatics Society (Gesellschaft für Informatik, GI) and Information Technology Society (Informationstechnische Gesellschaft, ITG). The 26th PARS Workshop took place on 7th and 8th May 2015, in Potsdam (Germany). The goal of the bi-annual PARS Workshop was the presentation of important research within the scope of PARS and an exchange of ideas between the participants.

Within the workshop, Exa2Green partners Martin Wlotzka and Vincent Heuveline (Heidelberg University) presented recent work on "Energy-aware mixed precision iterative refinement for linear systems on GPU-accelerated multi-node HPC clusters".

For more information: http://www.cs.uni-potsdam.de/bs/misc/workshops/2015/pars.html

Exa2Green at PASC15 Conference in Zurich (Switzerland)

PASC15 ("Platform for Advanced Scientific Computing") Conference, taking place at Zurich (Switzerland) from 1st to 3rd June 2015, provided an opportunity for scientists and practitioners to discuss key issues in the use of High Performance Computing (HPC) in branches of science that require computer modelling and simulations.

Within the conference, Exa2Green partner Joseph Charles from ETH Zurich presented a poster entitled "Computational and energy efficiency optimizations of the air quality prediction model COSMO-ART".

COSMO-ART is a regional atmospheric GCM consisting of the COSMO forecast model coupled with the chemical transport model ART (Aerosols and Reactive Trace gases). Joseph Charles presented several numerical approaches investigated within Exa2Green to optimize the energy footprint and performance of the model system. This effort utilises evolving COSMO optimisations within the PASC initiative. Furthermore, algorithmic changes demonstrated in the PRACE 2IP WP8 and an accelerated version of the Kinetics PreProcessor are used to improve the integration of chemical kinetics and thus lower energy requirements and computational cost of the gas phase chemistry model.

For more information: http://www.pasc15.org

Exa2Green at Euro-Par Vienna 2015

Researchers from Exa2Green partner Universitat Jaume I de Castellon presented their work on systematic fusion of CUDA kernels at the 2015 edition of Euro-Par, held in Vienna (Austria) from 24th to 28th August 2015, and hosted at the Vienna University of Technology. This work introduced a systematic analysis in order to fuse CUDA kernels arising in efficient iterative methods for the solution of sparse linear systems. The new methodology characterizes the input and output vectors of these methods, combining this information together with a dependency analysis, in order to decide which kernels to merge. The experiments on a recent NVIDIA "Kepler" GPU reported significant gains, especially in energy consumption, for the fused implementations derived from the application of the methodology to three of the most popular Krylov subspace solvers with/without preconditioning.

For more information:
http://www.europar2015.org

Exa2Green at ParCo 2015 in Edinburgh (UK)

Another presentation of Exa2Green results was done by partner Universitat Jaume I de Castellon (UJI) at ParCo 2015, the International Conference on Parallel Computing, taking place in Edinburgh (Scotland, UK) from 1st to 4th September 2015, hosted by the University of Edinburgh. This work exploited CUDA dynamic parallelism to reduce execution time while significantly reducing energy consumption of the Conjugate Gradient (CG) method for the iterative solution of sparse linear systems on graphics processing units (GPUs). In the new implementation, this solver is launched from the CPU in the form of a single “parent” CUDA kernel, which invokes other “child” CUDA kernels. The CPU can then continue with other work while the execution of the solver proceeds asynchronously on the GPU, or block until the execution is completed. Our experiments on a server equipped with an Intel Core i7-3770K CPU and an NVIDIA “Kepler” K20c GPU illustrate the benefits of the new CG code solver.

The group UJI presented, in collaboration with researchers from Queen's University of Belfast, a second work in the same conference. This work investigated the interplay among concurrency, power dissipation, energy consumption, and voltage-frequency scaling for a key numerical kernel for the solution of sparse linear systems. Concretely, the study targeted a task-parallel implementation of the Conjugate Gradient method, equipped with an state-of-the-art preconditioner embedded in the ILUPACK software, and targeted a low-power multicore processor from ARM.

For more information:
http://www.parco2015.org