ITEA 3

Project Results

H4H

Single hybrid programming environment: a competitive boost to European research and industry

Executive summary

The goal of the ITEA 2 H4H (Hybrid4HPC) project was to provide a highly efficient, hybrid programming environment for heterogeneous computing clusters to enable easier development of high-performance computing (HPC) applications and optimise application performance. More specifically, providing a new infrastructure for HPC cloud computing (Intel Xeon Phi in addition to Nvidia GPUs support, improved energy efficiency) and new cooling technology to reduce energy consumption.

Project origins

High-performance computing is essential in meeting demand for increased processing power for future research and development in many domains, such as aircraft and automotive design or multimedia. However, the lack of a hybrid programming environment to facilitate the development process for HPC applications and, more importantly, to maximise the overall performance of these applications prompted the challenge taken up by the H4H project.

Technology applied

Key to the technological progress achieved were the extensive collaboration and workshops in which the partners engaged to develop and test the various technologies, customisation and optimisation options, and ultimately produce significant innovations to all the H4H technology components. Support was improved for heterogeneous architectures (GPU / Xeon Phi) along with portability for the various types of architectures. New programming approaches (e.g. OpenACC, OpenMP 3.0 tasks, PGAS), faster development phases for applications developers and better use of application resources for an energy-efficiency objective were released or improved along with a new promising cooling technology for future extreme computing needs. In concrete terms, the MAQAO (Modular Assembly Quality Analyser and Optimiser) performance evaluation framework was enhanced with Xeon Phi support, the Scalasca 2.0 tool (performance optimisation of parallel programmes) was also improved and released during the project. Both tools were integrated in bullx supercomputer suite 4 and also in the common performance measurement infrastructure Score-P. The Vampir performance analysis tool was enhanced and provided more scalable/detailed performance analysis and visualisation for hybrid programmes. Furthermore, improvements in energy efficiency were gained by integrating power and energy consumption constraints into a resource manager for HPC while improvements made in FoREST and UtoPeak (OSS) resulted in an average 20% gain in energy efficiency at less than 5% loss in performance. A new advanced cooling design solution based on diphasic thermal exchangers saw 0.144K/W achieved on a target of 0.17K/W against a SotA of 0.22. The new bull SEQUANA blade baseline design revealed that Loop Heat Pipe (LHP) two-phase technology can improve the CPU cooling. Performance improvements (scalability through linear parallelisation) were also achieved for the CEA LIST image search engine.

Picture detection in a large multimedia data base (CEA-List)

Making the difference

The results of the H4H technology have already made their way to the customers. For instance, in open source, SLURM contributions (I/O, power consumption per job or group of users) were integrated and made available in SLURM 2.6.6 at the end of 2014. MAQAO is increasingly being used by large customers and will be integrated in the bullx scs4 update in 2015. FoREST and UtoPeak saw software releases in October 2014

while in terms of the software infrastructure, the bullx supercomputer suite AE 3.0, 3.1, 4.0 and 4.0 updates appeared between 2012 and 2014. This integrated suite supports accelerators and energy efficiency as well as improves profiling and performance analysis and optimisation tools like Score-P/Vampir/Scalasca/MAQAO and BullXprof. In terms of the hardware infrastructure, the bullx B515/525 blade server (embedding Xeon Phi or GPU cards) and bullx B715 (with DLC) were integrated in the Bull range for HPC servers and a patent was filed for the exploitation of a dedicated chip providing consolidated power data at firmware level; Bull has also been awarded some commercial contracts (TUD/ZIH and SurfSara are two). For application developers, several improvements have already been or will soon be integrated in their commercial products or programme releases. In addition, partners providing support and services to HPC application developers gain greater added value from upgrades of applications or simulation softwares, such as ATEME video coding tools, CEA-LIST Multimedia search engines, Dassault Aviation Aircraft Design codes, EFIELD electromagnetic fields modelling and simulation software, RECOM 3D combustion simulation, GNS finite element forming simulation (Indeed), INTES finite element analysis system (Permas), MAGMA casting process simulation tools, Fraunhofer SCAI LAMA/SAMG libraries, REPSOL Seismic imaging and reservoir simulation codes, SCILAB MPI and GPGPU versions .

Future prospects

The results of this project will significantly improve performance for critical HPC applications and enable software editors, for example, to extend their market share in simulation software, image processing, video compression, etc. European companies and research centres will be able to solve computationally-intensive problems much more swiftly and the development of a competitive European HPC industry will have a positive impact on employment in Europe.

Major project outcomes

Dissemination

- 200 dissemination actions were referenced over the four and a half years project.
- The project participated to major HPC conferences & journals: SC, ISC, Euro-Par, EuroMPI, HPCC, JDPC, CPE
- Partners also contributed in several parallel tools workshops & tutorials: ParCo, VI-HPS Tuning Workshops, Parallel Tools Workshops, ...

Exploitation (so far)

- bullx supercomputing suite 4 and bullx blades with accelerators and direct liquid cooling
- SCALASCA 2.2 (performance optimisation of parallel programmes)
- MAQAO 2.1.1 (analysis and optimisation of binary codes)
- VAMPIR 8.4 (performance analysis tool)
- TEMANEJO, OMP2HMPP, GNS OpenForm & Indeed, INTES Permas, Efield 6.1, Scilab 5.5.1 ...
- PAS2P (performance prediction tool for parallel programmes)

Standardisation

- Participation and contributions to OpenACC 1.0 and 2.0
- Participation to the MPI3 Forum
- Contribution to the development of Score-P and OTF2
- Participation to OpenMP
- Participation the OpenMPI forum

Patents

- Several patent applications filed:
  - i) a low-pressure plane evaporator of a two-phase capillary-pumped Loop Heat Pipe implemented on blade servers
  - ii) a dissipative component for high-efficiency cooling
  - iii) a system for a multi-stage two-phase capillary pumped Loop Heat Pipe implemented on a server cabinet for overall efficient cooling of the server.

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H4H

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Partners

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Spain

BMAT Licensing, S.L.
Datalab
Repsol YPF
Universitat Autònoma de Barcelona (UAB)

Sweden

Efield
Rogue Wave Software

Project start

October 2010

Project end

February 2015

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Project website

https://itea3.org/project/h4h.html