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Project Results

COLOC

Getting the best out of computational power

EXECUTIVE SUMMARY

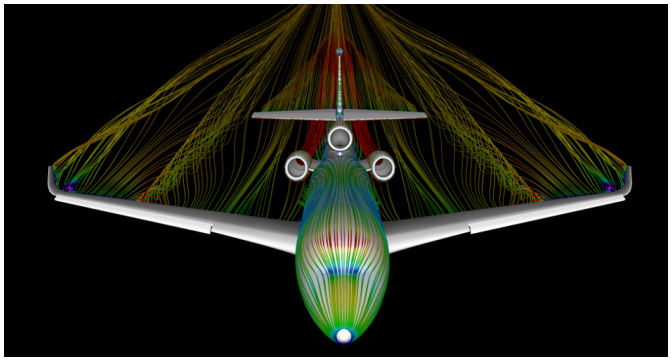
The ITEA project COLOC is a high-level technology project in which the development of a new approach to managing thread concurrency and data locality has led to impressive technical results. In turn, this has enabled a software engineering edge for creating and testing new models, mechanisms and tools for world-leading simulation software and applications.

PROJECT ORIGINS

With the increasing number of computing nodes – and number of cores per node – as well as new many-core accelerators, HPC applications developers are struggling to make efficient use of all these heterogeneous resources. Many applications achieve only poor global efficiency, especially because of their poor ability to handle and manage topology-aware data locality. Essentially, unless the locality problems (distribution, exchange and storage of data) are addressed, it will not be possible to improve data access performance and application execution to exploit the full hardware capabilities. The lack of abstractions and mechanisms to integrate both the vertical and horizontal dimensions of the software system stack, and thus facilitate high-performance computing, was the essential springboard for the COLOC project.

TECHNOLOGY APPLIED

The project developed a number of technology high points, a real engineering tour-de-force highlighted in the areas of modelling, profiling and measuring, solving, managing jobs and tasks, and managing parallel input/output (I/O). The Portable Hardware Locality (HWLOC) software package, which provides a portable abstraction of the hierarchical topology of modern architectures, primarily enables applications to gather information about modern computing hardware so as to exploit it accordingly and efficiently. Added to this was the Network Locality component that focuses on detecting network topologies, thereby assembling both server internal and network topology into a global map of the entire cluster or supercomputer. In terms of performance analysis, multiple enhancements were brought to the Modular Assembly Code Quality Analyser and Optimiser (MAQAO) developed by consortium member UVSQ (University of Versailles) in order to provide active support for application developers in analysing, porting and optimising their codes. These improvements include the implementation of the Micro-Ops Flow Simulator (UFS) and a new version of the Decremental Analyzer (DECAN), allowing to refine the diagnostics on data access performance by estimating the impact of latency and out of order mechanisms. This work was also facilitated by close collaboration between COLOC and the open source communities such as OpenMPI.



Streamlines behind a F8X business jet aircraft in landing configuration at low speed, as computed by the CFD tool. Front view. © Dassault Aviation

FOI (Swedish Defence Research Agency), was able to release for partners their extremely efficient out-of-core solver, FOISOL, that adapts the solution strategy according to the available core memory, thereby securing a solution at the expense of time. Not only did COLOC boost the efficiency of FOISOL but the project also provided possibilities for partners in cooperation with COLOC to study, analyse and find remedies to other problems such as I/O-bottlenecks that cause latencies in the dynamic scheduling of the computational resources in advanced massively parallelised multi-level solution procedures. Furthermore, in terms of job and task management, COLOC enhanced the design, development and validation of a standardised interface to enable the SLURM (Simple Linux Utility for Resource Management) Workload Manager to interact with applications to improve process placement algorithms using topology and data locality aware models created by HWLOC.

MAKING THE DIFFERENCE

In the field of aircraft (AC) design, the improved parallel efficiency of legacy CFD/CEM software and complex workflows for AC design, with the help

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of proto-applications and HPC/HPDA convergence readiness, has allowed Dassault Aviation to maintain its edge in aeronautics industry. On the back of the higher-level, power-crunching capacity generated by the COLOC project, Dassault has terminated its physical mock-up plant and has gone over fully to digital design for its military and civil aircrafts. The goals of ATOS/Bull for the next generation of data management capabilities have also benefited from being able to optimise the use of its HPC supercomputers and enhance applications for its customers, thereby improving its HPC offering. In fact, ATOS/Bull offers a commercial channel for the high-power computing technology developed in the COLOC project.

In the domain of computational electromagnetics (CEM), ESI Group/Efield has developed new and improved solvers in response to an increasing industrial demand for virtual testing tools with the ability to handle complete systems, such as cars and aircrafts, with integrated microwave components. Several successful benchmarks have been demonstrated in the project for applications such as performance of ADAS (Advanced Driver Assistance Systems) radars, stealth technology in aerospace and defence as well as applications in emerging domains like microwave curing of composites. With the commercial release of the new technology, Efield will be able to strengthen its competitive position in large-scale electromagnetic simulations and increase market share for full-system EM analysis.

The SME Scilab has developed flexible, easy to use access to heterogeneous HPC clusters and optimised code on heterogeneous architecture for non-HPC experts. Scilab has also integrated access to MUMPS software. The technology developed in the COLOC project has helped Teratec to consolidate its position as an HPC ecosystem player as well as promote itself on a wider European level. Inria has extended its HWLOC/NETLOC software packages and ATOS has developed a proxy IO technology to overcome current supercomputer architecture limitations inherited with the LUSTRE file system limitations, in order to prepare for Exascale future simulations. ATOS did also extend SLURM resource manager with topology-aware allocation capabilities combined with Inria's technologies such as HWLOC and TREEMATCH. UVSQ's new release of its open source tools has been incorporated in an Intel technology transfer programme.

MAJOR PROJECT OUTCOMES

Dissemination

- Presentation of project results at conferences (ICDCN, Teratec Forums, DIF) and websites
- Workshops on Data Locality, Topology-aware Resource Management for HPC applications, and Performance Optimisation (Euro-Par, HPCN, VI-HPS, Scalable Tools Workshop)
- Papers in e.g. the International Journal of High Performance Computing Applications

Exploitation (so far)

- Bull supercomputer suite version 5 for BullSequana X supercomputers integrates Proxy IO feature developed in COLOC project
- NETLOC Portable Network Locality open source software package allows network topology discovery and abstract representation, HWLOC companion developed within COLOC
- MAQAO cycle-accurate simulator module (UFS) to identify data access related bottlenecks
- DC-lib (Divide and Conquer) and FMM-lib (Fast Multipole Method) open-source C++ libraries to facilitate implementation of task-based thread parallelism in FEM software using unstructured meshes and of fully asynchronous message passing using GPI in FMM software
- Scilab sciGPGPU provides GPU computing capabilities to Scilab open source software for numerical computation
- EFIELD CEM One integrated HPC solvers optimized within COLOC in its software package such as MLFMM, FTDTD, FEM and MDMM solvers
- FOISOL (from FOI) an MPI and OpenMP massively parallelised direct linear equation solver
- Scilab cloud application framework allowing easy-to-use application deployment within standard and HPC cloud resources

Standardisation

- Slurm open source community (Layouts, Job Packs)
- Open MPI open source community with PML* monitoring integrated in OpenMPI 2.0

ITEA is a transnational and industry-driven R&D&I programme in the domain of software innovation. ITEA is a EUREKA Cluster programme, enabling a global and knowledgeable community of large industry, SMEs, start-ups, academia and customer organisations, to collaborate in funded projects that turn innovative ideas into new businesses, jobs, economic growth and benefits for society.

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Partners

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Dassault Aviation
Inria
Scilab enterprises
Teratec
University of Versailles Saint Quentin

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Swedish Defence Research Agency (FOI)

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