

EXA₂CT

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EXA₂CT

CREATING BREAKTHROUGH INNOVATIVE ALGORITHMS AND NEW PROGRAMMING MODELS, PAVING THE WAY TO EXASCALE FOR LEADERSHIP CLASS CODES.

The EXA₂CT project brings together experts at the cutting edge of the development of solvers, related algorithmic techniques, and HPC software architects for programming models and communication.

It will take a revolutionary approach to exascale solvers and programming models, rather than the incremental approach of other projects.



We will produce modular open source proto-applications that demonstrate the algorithms and programming techniques developed in the project, to help boot-strap the creation of genuine exascale codes.

Start from existing, leadership class applications running on Tier-0 systems today and extract knowledge about them to create the appropriate Proto-Applications.

Enhanced Numerical Algorithms Scalable, Pipelined, Robust Numerical Solvers

- that scale up to exascale performance
- that survive hardware failures

Enhanced Programming Models GPI/GASPI, Shark,

Efficient Stencil Code, PATUS

- communication model
- to deal with platform heterogeneity
- to deal with resilience





Strategy

Numerical Algorithms

Current linear solvers will not scale well to exascale, because of

- Global communication
- Bandwidth : Insufficient arithmetic intensity
- Lack of Resilience

Beyond state of the art

- Extend communication avoiding/hiding
 - Add preconditioning, add augmented/blocked/deflated systems

IT4Innovations

della Svizzera italiana

- Exploit arithmetic intensity using *tasking models* as backend
- Resilience through interpolation/algorithm-based fault tolerance (ABFT)
- Domain decomposition, using FETI methods as an example



Numerical Algorithms, an example

P. GHYSELS, T.J. ASHBY, K. MEERBERGEN AND W. VANROOSE



Next generation solvers can hide these latencies and boost performance of a wide range applications in complex systems.

Pipelined GMRES overlaps dot-product global communication latency with SpMV



Numerical Algorithms, an example

Report on the

P. GHYSELS, T.J. ASHBY, K. MEERBERGEN AND W. VANROOSE

Pipelined GMRES shows significant speedups compared to standard GMRES for strong scaling experiments



Programming Models

Current HPC programming models don't scale very well

- MPI, OpenMP, Vectorization
 - ... too complex
- PGAS Languages

... are a partial solution

Beyond State of the Art

- Extend PGAS with Tasking Models ... starting from GASPI
- High Level Libs : Patus, Shark
- Resilience : Software that survives failures





Programming Models

Tasks

Formulate your program in terms of logical tasks, instead of threads Threading Building Blocks , Cilk[™] Plus, ...





GASPI – a PGAS API

- is not a new language or a language extension, but complements existing languages (library approach ~ MPI)
- Support for resilience

e.g. time-out mechanisms for all non-local procedures

GASPI + Tasks → extreme scalability

Opportunities : Heterogeneous execution platforms for tasks, task/data migration, task/data resilience, ...





Application

Proto-Apps



Sometimes considered identical to Mini-apps, Proxy-Apps, Skeleton Apps



However proto-apps are not reduced version of real-world applications, they are specifically designed to be :

- demonstrating high scalability for re-factored applications
 - encapsulating essential characteristics:
 - New exascale algorithms
 - Advanced parallel implementations



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Proto-Apps



Scientific & Industrial Board

- Define the selection of the proto-apps
 - Have a say in the definition of the targets
 - Are preferred partners in the take-up of the results
 - Will get help in translating the proto-app (back) into the reference applications

Reference Application Areas

- Computational Fluid Dynamics for Aerospace, combustion
 - Structural Mechanics Analysis
 - Geophysics
 - Material sciences
 - And others ...



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Exa2ct

XA2C

PROTO-APPLICATIONS Marie-Christine Sawley, Intel

NUMERICAL ALGORITHMS

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EXA2CT EXA2CT Project Home Page Numercal dimutation is a couldar part of adaptive and industry in Surgers. The analysis adaptive more computational resources for increasingly compute interactive mode brain more than a disposing installation. This is the device for the solution to exceed a local to lead to be increased in single processor performance. Rescale moderns will may on material brains of dimotorial to the solution will be compared installation adaptive more installation and the solutions. We a compared installation adaptive to the solution of dimotorial states of the solution in the solution in the solution is the solution of the solution is a solution of the solution is the solution of solution and the solution adaptive solution adaptive solution adaptive solution and the solution of the solution of the solution of the solution adaptive solution adaptive solution is a solution solution of the solu Numerical simulation is a crucial part of adants and industry in Surgia. The 1000 · Annut Agent and Events · Public Droumants · Dousts Documents a Contact The DALET around have been associated the rating wigh at the development of the bounds' project longer topologic experience of the voltring engines of the consequence of sociality, module engineering backwares, and toff and some profiles to a programming regions and assemulations () will have a recondence of species) to assess recomm which not accompany of the last a second way approach to conside where and programming works, where has not consider sparsately the ord prob-minute many modes, where applications that descended. Its significant and programming functions developed in the project, in they had show the order of descendences functions developed in the project. In they had show the order of Fraunhofer C (Editory of lasts nas inte Innia VERSAULES e a intrastructure

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