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Peano4/ExaHyPE

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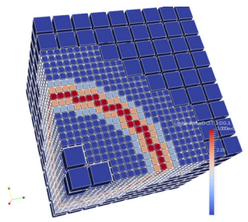
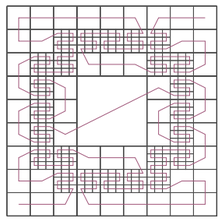
http://www.peano-framework.org/

Peano





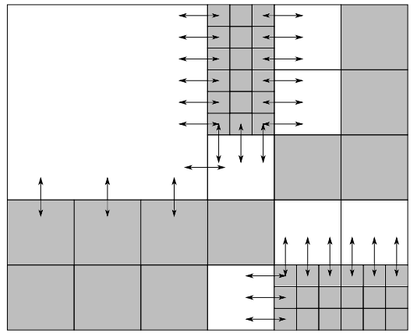
- Dynamically adaptive cartesian meshes
- Block structured AMR
- Space filling curves for domain decomposition

ExaHyPE

$$\frac{\partial Q}{\partial t} + \nabla \cdot F(Q) + \sum_{i=1}^{d} B_i(Q) \frac{\partial Q}{\partial x_i} = S(Q) \qquad \text{with } Q : \mathbb{R}^{d+1} \mapsto \mathbb{R}^m$$

- Engine for solving hyperbolic PDEs (e.g. seismic, gravitational waves)
- Scalable infrastructure
- ADER-DG + FV
- C++, MPI, OpenMP
- User: thin Python layer for code generation

Enclave tasking

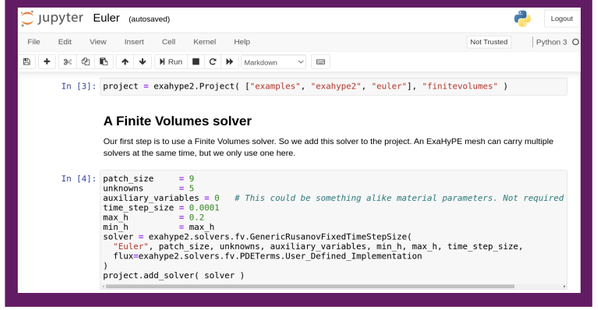


High priority Skeleton cells (white):
- at AMR boundaries
- take part in MPI exchanges
- spawn tasks

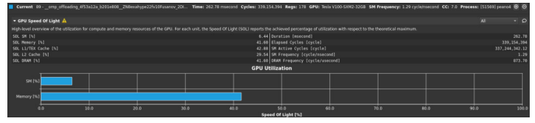
Low priority Enclave cells (gray):
- computationally intense
- scheduled by (OpenMP) runtime
- run on host or device
- overlap with Skeleton tasks

ExaHyPE
An Exascale Hyperbolic PDE Engine

User code



GPU offloading



- OpenMP + LLVM (+ CUDA)
- Restructuring of functions to increase concurrency
- Offload expensive low priority ("Enclave") tasks
- Routinely millions of threads on V100 (Bede)
- Todo: OpenMP + GNU, Intel compilers

References

Clawpack Development Team (2020), Clawpack Version 5.7.1, http://www.clawpack.org, doi: 10.5281/zenodo.4025432

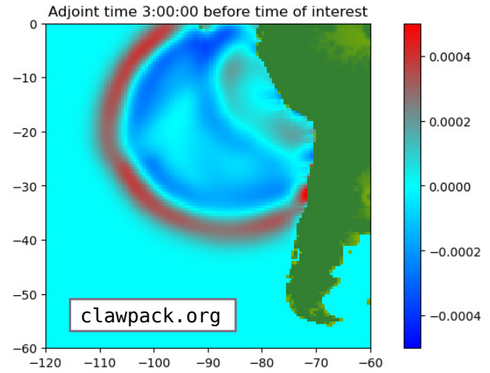
Weinzierl, T.. “The Peano Software—Parallel, Automaton-based, Dynamically Adaptive Grid Traversals.” ACM Transactions on Mathematical Software (TOMS) 45 (2019): 1 - 41.

Enclave Tasking for DG Methods on Dynamically Adaptive Meshes Dominic Etienne Charrier, Benjamin Hazelwood, and Tobias Weinzierl SIAM Journal on Scientific Computing 2020 42:3, C69-C96

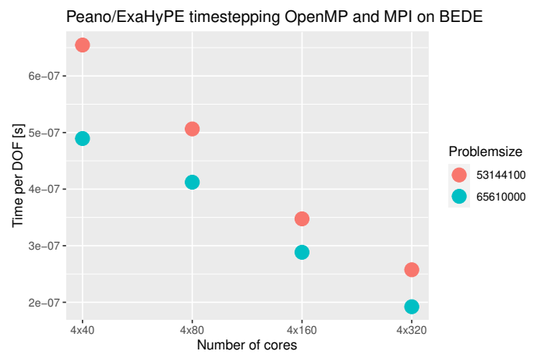
ExaHyPE: An engine for parallel dynamically adaptive simulations of wave problems, Reinarz et. al., Computer Physics Communications 2020, V254, 107251

Clawpack support

- Fortran adapter + python glue code couple Clawpack to peano
- Shallow water simulation done
- Next: Read in bathymetry and simulate Chile tsunami



Scaling



- CPU only scaling on Bede
- Computationally cheap Euler

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