

Key Application #1: Geodynamics



Perturbation of average s-wave velocity by convection processes in the Earth's mantle; simulation combines a numerical convection (100 mio. finite elements) with a mineral physics model

code TERRA

- mapped icosahedron
- multigrid method as core solver



Technical specifications:

- TETHYS currently consists of 80 compute nodes and one cluster head
- each compute node consists of two AMD processors with the following specifications

no. of processors	two per node
type of processors	AMD Opteron 250
	(64 bit, single core)
clock speed	2.4 GHz
L1 cache	64/64KB (data/instruction)
L2 cache	1MB (data + instruction)
local memory	2 GB RAM (DDR1)
local storage	160 GB
network interface	1000T Ethernet (2 ports)
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- (Sarge) AMD64 port

- MPICH and OpenMPI
- 2013

Benchmarks:

Performance tests with mantle convection code TERRA show good scalability:





 $(MT = 64, 128, 256 \leftrightarrow resolution 100, 50, 25 \text{ km} \leftrightarrow 1, 10, 85 \text{ mio. grid points})$

For 500 time-steps we obtain a run-time of 2002 s (mt=128 case on 16 processors) and 2564 s (mt=256 case on 128 processors), which both lead to the same workload per processor.

TETHYS – A Tectonic High-Performance Simulator for Geophysical Computations

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- We use Paraview to visualise simulation data: • Paraview can be run with MPI (data distri-
- filter operations are performed in parallel, only the polygonal surface data is sent to the graphics client/front-end
- front-end
- 3D stereo projection is possible with a dual head graphics card (quad buffered) and two projectors (polarising filters)
- this simplifies the interpretation of structures with a complicated spatial distribution

- SpecFEM3D to date the only method avail-• high order finite elements \rightarrow high accuracy
- high geometrical flexibility \rightarrow smooth representation of complex structures, topogra-
- parallel implementation comparatively easy
- 3D anisotropy, 3D attenuation and effects of

Key Application #3: Local Seismology



colours indicate partitions generated by Metis partitioning tool

Interconnect topology:



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References:

- Debian GNU/Linux http://www.debian.org
- FAI http://www.informatik.uni-koeln. de/fai/
- PVFS2 http://www.pvfs.org
- every desktop computer can be used as



SeisSol – simulation of seismic wave propagation with the arbitrarily high order discontinuous Galerkin method

- p-adaptive ADER-DG (Arbitrary high order DERivatives) scheme
- unstructured tetrahedral meshes \rightarrow highly complex 3D models
- local time stepping for strongly varying tetrahedral mesh spacing
- load balancing for parallelisation requires weighted mesh partitioning





Example result from Intel MPI Benchmark Suite (IMB): test of Exchange communication pattern (data exchange with left and right neighbour in processor chain)

- muenchen.de/Members/kaeser/
- IMB http://www.intel.com/cd/software/ products/asmo-na/eng/219848.htm
- GeoComputing group Munich http://www.geophysik.uni-muenchen. de/research/geocomputing
- Oeser, J., H.-P. Bunge, and M. Mohr; Cluster Design in the Earth Sciences: TETHYS; in High Performance Computing and Communications – Second International Conference, HPCC 2006, Munich, Germany, eds. M. Gerndt and D. Kranzlmüller; Lecture Notes in Computer Science, vol. 4208 (2006), Springer