Elitenetzwerk Bayern

UNIVERSITÄT BAYREUTH

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Date: 23.01.2020 | Time: 4:30 pm | Location: H19, Building NW II

Coffee/tea from 4:00 pm in the seminar room 748, NW II

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Solvers for extreme scale computing

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Abstract: In this talk we will demonstrate how linear systems with a trillion (10^{12}) degrees of freedom (DoF) can be solved by modern parallel algorithms. That this is not a trivial problem can be understood when considering the energy cost of computing. In fact, for extreme scale computing, energy consumption is increasingly perceived as a fundamental bottleneck. For the argument here, we may assume that executing a floating point operation (FLOP) costs 1 nJ. In consequence, executing 10^{24} FLOP would consume 277 GWh.
This simple argument shows that for problems with 10^{12} DoF it is impossible to use algorithms of quadratic or worse complexity. Only scalable algorithms with linear complexity are suitable. In particular, no doubly nested loop over the unknowns must ever occur.
In other words, and somewhat counter-intuitively, the efficiency of algorithms becomes more important with more powerful computers. This said, we will introduce the parallel multigrid algorithms developed in the TerraNeo project. Multigrid algorithms have linear complexity so that we could use them to solve a system arising from the discretization of Stokes equation with ten trillion (10^{13}) unknowns. Here we point out that the solution vector requires 80 TByte of memory. Even with efficient data structures exploiting sparsity, no existing computer has enough memory to store the system matrix. Therefore it is crucial to have a matrix-free implementation and a carefully designed software, optimized for best possible parallel efficiency. With such a solver we can now compute the dynamics of the Earth Mantle on a finite element mesh that resolves the planet's volume with a resolution of about 1 km.