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Finite Element Methods at Realistic Complexities

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Solving realistic, applied problems with the most modern numerical methods introduces many levels of complexity. In particular, one has to think about not just a single method, but a whole collection of algorithms: a single code may utilize fully adaptive, unstructured meshes; nonlinear, globalized solvers; algebraic multigrid and block preconditioners; and do all this on 1,000 processors or more with realistic material models.

Codes at this level of complexity can no longer be written from scratch. However, over the past decade, many high quality libraries have been developed that make writing advanced computational software simpler. In this talk, I will briefly introduce the deal.II finite element library (http://www.dealii.org) whose development I lead and show how it has enabled us to develop the ASPECT code (http://aspect.dealii.org) for simulation of thermal convection. The project also builds on a variety of other libraries (e.g., p4est, Threading Building Blocks, and Trilinos) that provide parallelism at various levels. I will discuss some of the results obtained with this code and comment on the lessons learned from developing this massively parallel code for the solution of a complex problem.

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