Massively Parallel Finite Element Programming in deal.II

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Implementing parallel adaptive mesh refinement in solvers for partial differential equations is complex and often results in code tailored to specific problem domains, code without the ability to scale to a large number of machines, or often both. We present algorithms and data structures to do neither, i.e. a generic finite element code with adaptive mesh refinement and with good parallel scalability.

We extended the existing finite element library `deal.II` ([1, 2]) to support massively parallel computations. Here we describe the steps done in enabling `deal.II` to scale from less than a hundred cores and a few million unknowns up to thousands of cores and more than a billion unknowns. This is done in a general setting applicable to any generic finite element library, c.f. [3].

The description of algorithms of data structures to do this, will be accompanied by numerical results from different applications.

References

[1] W. Bangerth and G. Kanschat. `deal.II` Differential Equations Analysis Library, Technical Reference. http://www.dealii.org/, 2012.

[2] W. Bangerth, R. Hartmann, and G. Kanschat. `deal.II` — a general-purpose object-oriented finite element library. *ACM Trans. Math. Softw.* **33,** 4, 24/1–24/27, 2007.

[3] W. Bangerth, C. Burstedde, T. Heister, and M. Kronbichler. Algorithms and Data Structures for Massively Parallel Generic Finite Element Codes. *ACM Trans. Math. Softw.*, **38**(2), 2011.