Achievements 2012-13

64-bit indices: Most finite element software is limited by 32-bit integers to computations with less than 2B unknowns and ~20k processors. We have extended deal.II and Trilinos to optionally use 64-bit indices instead and verified scalability on model problems up to 27B unknowns. We have also verified scaling on real applications up to 8,000 cores.

More modern installation support: Supporting more users outside the core CS&E area requires making installation easier. We have switched from Autoconf to CMake to benefit from better external support and to make integration into modern, user-friendly IDEs easier.

Achievements 2013-14

Better support for multicore machines: Most code is still written and tested on multicore laptops, desktops or workstations. We have extended support for shared memory parallelization within the library and within the user interfaces. Many operations now scale well up to at least 64 cores in a single machine, reaching all the way to current high-end workstations.

Support for GPUs and Intel MIC: Support for GPUs is important not only because of the large number of current Top500 supercomputers using them but also because the DOE committed to this architecture with Summit (ORNL) and Sierra (LLNL). Intel MIC has already been adopted by several Top500 supercomputers, including number one, the Tianhe-2. Support of these new architectures in deal.II is being added using the Paralution library and Tpetra of Trilinos.

Vectorization: SIMD instructions of modern CPUs work on important larger data (256 bits on recent x86-64 and 512 bits on future Intel CPUs). Using OpenMP 4.0 SIMD instructions, we have enable the vectorization on most of our vector-vector and vector-matrix operations.

Support MueLu: Add support for the MueLu package of Trilinos. This new algebraic multigrid package has been developed to replace ML.

More accurate geometries: deal.II now handles curved and complex geometries much better than before. This includes curved elements in the domains, and interfaces to CAD tools.

Move to GitHub: We have changed our version control system from svn to git in 2014/07 and we now host the deal.II repository on GitHub (https://github.com/dealii/dealii). Since the migration 2,131 issues or improvements have been reported or contributed by 75 developers of which 1,994 have been merged or solved already. (1,650 in 2015, with 95 still open).

Achievements 2015-16

Support for C++14: Refactoring of our codebase to new standards of the C++ language allows us to simplify the code and keep up-to-date with modern language features.

Support for parallel adaptive geometric multigrid: deal.II has long had support for geometric multigrid algorithms for sequential computations. On the other hand, parallel computations require complex communication and load-balancing algorithms for the different mesh hierarchy levels. deal.II now supports such computations, and some simulations have been shown to scale to 20B unknowns and more than 10,000 cores.

Improved support of complex valued problems: Some problems, such as frequency-domain PDEs are formulated as a complex valued problem. The existing support for complex vectors and matrices has been improved to more parts of the library.

Fig. 1: deal.II is widely used, with ~600 mailing list members and 120+ known publications in 2015 reporting results obtained with it.

Fig. 2: deal.II is continuously developed, with ~3750 commits in 2015. Note the contribution spikes during the NSF funded workshops 2013/08 and 2015/08.

Fig. 3: Scalability of one of the dominant operations of the code shown in Fig. 2, for a single MPI process run on a shared memory multicore machine. The old implementations (1,2) of multicore support only scaled to ~8 cores. The new code (implementation 3) allows for more efficient use of current and future workstations or laptops. (Credit: B. Turcksin, M. Kronbichler and W. Bangerth)

Fig. 4: Example application of an ASPECT convection in the Earth’s mantle. The shown model was run on 2,000 cores and involves ~100M unknowns.