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DISCONTINUOUS GALERKIN FOR HIGH PERFORMANCE COMPUTATIONAL FLUID DYNAMICS

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In this talk we present a high order discontinuous Galerkin spectral element based framework for the simulation of compressible turbulent fluid dynamics, e.g. [1].
An important ingredient to achieve high performance is the efficient single processor implementation of the resulting algorithms, which we demonstrate by comparing specific CPU timings to another framework based on traditional finite differences. We show as well that by drastically decreasing the load on a processor (up to one element on a processor left only), it is possible to make use of strong caching effects.
Besides the single processor performance, special focus is on the parallel implementation of the scheme. For this, a new three-dimensional unstructured code is developed from scratch tailored to simulations on $> \mathcal{O}(10^5)$ MPI processes. We show how to make use of the structure of the discontinuous Galerkin operator by splitting the operator in pure local parts and parts that need neighbor data, i.e. communication. By use of a non-blocking MPI communication strategy, this allows us to basically hide the communication overhead with local work.
We demonstrate the MPI performance of the framework on the new IBM BlueGene/Q supercomputer JUQUEEN of the research center Jülich, with strong scaling results of compressible turbulent simulations on up to $260,000$ MPI processes with sustained parallel efficiency of over 90%, even when using one element on a processor only.

REFERENCES

[1] F. Hindenlang, G. J. Gassner, C. Altmann. A. Beck, M. Staudenmaier and C.-D. Munz, Computers&Fluids **61** (2012).