RÉPUBLIQUE FRANÇAISE
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ONERA
THE FRENCH AEROSPACE LAB

InterFLOP: Mid-Year Meeting 06/10/21

E. Martin
ONERA – DAAA/NFLU

Task 6 : Application cases and Users technical board

- Application: ONERA *Aghora* code (*)
  - A high-order DG solver for compressible turbulent flows in aerodynamics
  - Motivation: industrial demand for accurate solutions
- Numerical scheme: Discontinuous Galerkin method (DG) in space
  - Piecewise polynomial approximate solution
  - Spatially high-order accurate numerical schemes with compact stencil
- Time implicit integration
  - Parallel iterative Krylov solvers (flexible GMRES, deflation, Block ILU(0))
- Several challenges
  - **Large** and **ill-conditioned** sparse linear systems
    - Needs of **robust** and **efficient** Krylov solvers
  - High-computational cost and large memory requirements
    - Code optimization techniques, **mixed-precision algorithms**

(*) F. Renac, M. de la Llave Plata, E. Martin, J. B. Chapelier, V. Couaillier, *Aghora: A High-Order DG Solver for Turbulent Flow Simulations*, in: Notes on Numerical Fluid Mechanics and Multidisciplinary Design, Springer International Publishing, 2015, pp. 315-335.

Task 6 : Application cases and Users technical board

- Feedback
  - Sensitivity to the compiling options (Intel and GNU)
    - Difficulties to determine which portions of the code are involved
  - Improve arithmetic intensity: data structures redesign, operators packing
    - Choice of the **polynomial degree *p*** has a **crucial impact** on performance
    - Strategies might accelerate both low and high degrees ($1 \leq p \leq 5$)
    - Not easy to identify best scenario as the code could be memory-bound
  - Mixed-precision algorithms during the **Krylov solver preconditioning step**
    - Used daily but there are still some open questions:
      - Best practices ? Safeguards ?
      - All operations are really well declined ?
      - Which precision is needed ? What gains could be expected ?
  - Numerical instabilities
    - An easy way to check behavior of certain sensitive functions of the code ?