Capability of CABARET Aeroacoustics and Geophysical Fluid Dynamics Solvers Improved by HECToR dCSE Team

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An HPC expert from NAG, working under NAG's Computational Science and Engineering (CSE) support service for HECToR, the UK's national academic supercomputing facility, has assisted in upgrading the parallel implementations of two very important Computational Fluid Dynamics (CFD) applications that use the CABARET method.

CABARET (Compact Accurate Boundary Adjusting high REsolution Technique), is a general-purpose numerical scheme which may be used to solve the complex flow of liquids and gases, is well suited for computational aeronautics and geophysics problems. One application of CABARET is in the investigation of aircraft noise, which is currently a very important environmental concern. A significant component of all aircraft noise results from air flowing around the airframe, engines, and wing flaps. Reducing this noise remains a very challenging design problem that requires this model to accurately simulate the wing-flap, free jet, and wing-flap-jet interaction effects that can occur so they can be minimised. Another CABARET application simulates medium to large scale circulation effects of eddys in the ocean, which is a major concern in the study of climate change.

Commenting on the dCSE project success, *Dr Sergey Karabasov of the School of Engineering and Materials Science at QMUL said: "The dCSE project has been mainly (75%) focused on extending the general CABARET method to wider scientific applications. Specifically, thanks to this project a new computational Geophysical Fluid Dynamics (GFD) code PEQUOD (the Parallel Quasi-Geostrophic Model) has been introduced to HPC for high-resolution ocean modelling simulation at eddy-resolving regimes. This work has already led to secure NERC funding for a new 3 year project "Turbulent Oscillator" (Dr Berloff, PI) and Dr Karabasov, Co-I) where the HPC PEQUOD code will be used to study long-scale variability in oceanic flows."*

This work has enabled PEQUOD to achieve a 2 times speedup, and also make more efficient use of more cores on HECToR.

"The remaining 25% of the current dCSE project has been used for improving I/O of the unstructured CABARET code used for aeroacoustics applications. This work has been essential since the original way of postprocessing results of the CABARET calculations was largely serial which was beginning to cause problems on HPC file systems. The dCSE software support has been very useful for the code development."

HECToR

HECToR is managed by EPSRC on behalf of the participating Research Councils with a mission to support capability science and engineering in UK academia. The Cray XE6 supercomputer, located at the University of Edinburgh, is managed by UoE HPCx Ltd. The CSE Support Service is provided by NAG Ltd and ensures users have access to appropriate HPC expertise to effectively exploit advanced supercomputers for their science. A critical feature of the CSE Support Service is the distributed CSE (dCSE) programme which, through lightweight peer review, delivers dedicated performance and scalability projects on specific codes in response to proposals from users. The dCSE programme now consists of over 70 focused projects complementing the traditional HPC user applications support and training also provided by NAG.

The dCSE projects completed so far have delivered outstanding examples of the cost savings and new science that can be enabled through dedicated CSE effort. The project for the CABARET based codes reported here adds to these success stories with a successful performance improvement.

Project Background

One of the objectives of this dCSE project was to improve the scalability of one of the CABARET applications, the Parallel Quasi-Geostrophic Model (PEQUOD), which is used for modelling transient oceanographic phenomena such as circulating eddies in the ocean. Another objective was to improve the I/O efficiency of a second application, Cfoam-CABARET, which is used for modelling noise caused by aircraft jet engine-flap interactions.

Dr Sergey Karabasov of the School of Engineering and Materials Science at QMUL was the Principal Investigator for the project, Dr Pavel Berloff of the Department of Mathematics at ICL was the Co-Investigator for the project. Phil Ridley of NAG carried out the 6 person-month project, in close collaboration with the NAG CSE team.

Project Results

The improvements to PEQUOD have enabled the application to achieve a 2 times speedup for a representative grid size of 1025, and furthermore, good scalability can now be achieved for grids of up to 16385 points, using 512 cores on HECToR Phase 3. To improve efficiency of Cfoam-CABARET, I/O using MPI for doing checkpoint/restart and generating visualisation data files eliminated the need for many thousands of files to be present at run-time, thereby enabling a more practical use of the application on HECToR.

A full technical report on this work can be found at http://www.hector.ac.uk/cse/distributedcse/reports/cabaret02/

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