APPLICATION BRIEF

ARCHER Flexes Its Muscles on Code_Saturne

Code_Saturne

Code_Saturne is an open source computational fluid dynamics (CFD) application primarily developed by EDF R&D in France. It solves Navier-Stokes equations for 2-D, 2-D axisymmetric and 3-D flows, steady or unsteady, laminar or turbulent, incompressible, weakly dilatable and compressible, isothermal or not, with scalars transport. Several turbulence models are available, from Reynolds-averaged models to large eddy simulation models. In addition, a number of specific physical models are also available as modules including gas, coal and heavy-fuel oil combustion, semi-transparent radiative transfer, particle-tracking with Lagrangian modeling, Joule effect, electrics arcs, weakly compressible flows, atmospheric flows, and rotor/stator interaction for hydraulic machines.

ARCHER: The U.K.'s National HPC Service

ARCHER (Advanced Research Computing High End Resource) is the U.K.'s national HPC service for academic research. The system is funded by the U.K. Research Councils, housed at the University of Edinburgh's Advanced Computing Facility, supported by EPCC and Daresbury Laboratory, and managed by the Engineering and Physical Sciences Research Council (EPSRC). The 1.56-petaflop Cray XC30 supercomputer supports a range of science from climatology to nanoscience.

Cray® XC30™ 'ARCHER' System

- Cabinets: 16
- Peak performance: 1.56 petaflops
- Compute nodes: 3,008 with two 12-core Intel® Xeon® E5 series processors per node
- Cores: 72,192
- Interconnect: Aries
- Storage: 4.4 PB of Cray® Sonexion® scalable storage

Situation

As worldwide demand for energy increases, so do the challenges associated with its production and efficient and safe use. An immediate effort being carried out in the United Kingdom by EDF Energy consists of extending the lifetime of existing nuclear power plants. Doing so requires the safe control of operational parameters and the ability to anticipate cracks and gas leaks. Ideally, physical checks and measurements of the reactors would provide the necessary data, but access to certain parts is difficult.

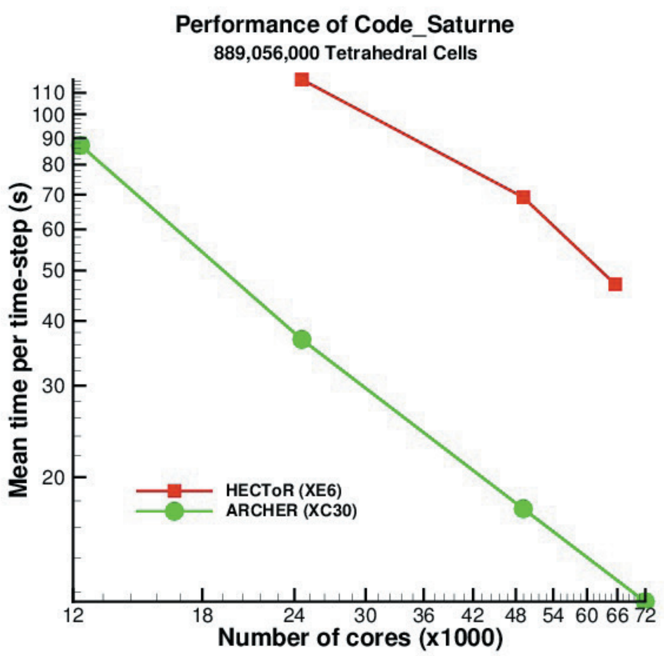
Given the restrictions to physical experiments, researchers have turned to high performance computing (HPC) and computational fluid dynamics (CFD) to model the multi-physics problems involved in nuclear reactor fluid flows. CFD uses grids with millions of elements and getting the required fidelity from these simulations depends on effective use of HPC. To that end, the effort to improve CFD-HPC software is ongoing.

Solution & Result

Code_Saturne is a multi-purpose CFD application well suited to the fluid flow simulations required by the nuclear reactor work (see sidebar). As part of the ongoing CFD code improvement effort and in preparation for more extensive production runs, scientists from EDF Energy and STFC Daresbury Laboratory tested the performance of Code_Saturne on ARCHER, a 1.56-petaflop Cray® XC30™ supercomputer that serves as the U.K.'s national HPC service for academic research.

The researchers' test case was designed to challenge the code at scale. They built a 0.9 billion-cell mesh by mesh multiplication from an originally smaller mesh (each cell is split in eight and this process is repeated). The mesh was unstructured (tetrahedral cells only) and they computed the flow in a lid-driven cavity (cubic box with a horizontal constant velocity imposed at the top wall).

ARCHER — their test system for the code — is equipped with 12-core 2.7 GHz Intel® Xeon® E5 series processors, 64 gigabytes of memory per node, and the Aries interconnect with multi-tier all-to-all connectivity. With this combination of technologies they achieved results about three times faster than previous, similar tests on HECToR, a Cray® XE6™ system and ARCHER's predecessor. That same speed up was observed up to 72,000 cores (3,000 nodes), demonstrating the system's capability for scaling to its full size.



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