Performance evaluation of the General Equation and Mesh Solver (GEMS)

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ABSTRACT

The General Equation and Mesh Solver (GEMS) is a computational fluid dynamics (CFD) code originally developed at Purdue University by Dr. Charles Merkle's group, and currently maintained by Dr. Stephen D. Heister's and Dr. William E. Anderson's research groups in the Department of Aeronautics and Astronautics at Purdue University [1, 5, 4]. GEMS is a multi-physics solver, capable of handling multi-component mixtures with detailed chemical kinetics. One of the areas of research where GEMS has provided important insights is the study of combustion instabilities in rockets and gas turbines [3, 6]. The code is actively used in academia at Purdue University, and in government at the Air Force Research Laboratory.

GEMS is written in Fortran 90/95 and consists of 20 different modules containing approximately 30,000 lines of code. GEMS adopts a distributed programming model for parallel execution, and can be run on parallel architectures and clusters via MPI.

The Conte cluster [2] at Purdue University was used to evaluate the performance of GEMS. Conte has 580 nodes, each with two 8-core Intel Xeon-E5 processors (Sandy Bridge) and two Intel Xeon Phi coprocessors. On Conte, a typical combustion instability simulation can run for up to 2 months using 960 processors. The results from this study will be used to optimize the code and improve its performance.

For this work, we performed a comprehensive evaluation of the GEMS software on Conte's Intel Xeon processors. Our results include observations obtained from running GEMS with a variety of workloads and with an increasing number of processors. In addition, GEMS was profiled using Intel VTune Amplifier to identify computationally intensive sections of the code, also known as *hotspots*. To better understand GEMS' memory utilization, we also analyzed memory access patterns using Intel VTune Amplifier, and identified potential memory issues using Intel Inspector. Furthermore, we used Intel Advisor to evaluate the potential performance gain that could be obtained from parallelizing the identified *hotspots*.

These analyses helped us identify and replace specific user defined routines relying on intrinsics with optimized threaded math libraries, such as Intel's Math Kernel Library (MKL). The results from this comparison will be presented. In addition, our study also helped identified sections of the code that could benefit from improving data accesses the working data set to minimize the cache misses.

Our poster will also feature ongoing optimization efforts aimed at expressing further parallelism in GEMS through the addition of threading in sections of the code identified by this study. Finally, we will present preliminary performance results of GEMS on the Intel Xeon Phi architecture.

Keywords

CFD, GEMS, profiling, performance analysis, Conte cluster

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