Adaptive Discontinuous Galerkin Method for Compressible Flows Using Charm++

Weizhao Li[1], Aditya K. Pandare[2], Jozsef Bakosi[2], Hong Luo[1]

[1]) Department of Mechanical and Aerospace Engineering,
North Carolina State University
[2]) Computer, Computational and Statistical Sciences,
Los Alamos National Laboratory

In this presentation, we propose a parallel hp-adaptive discontinuous Galerkin method for the compressible flows which exercises load balancing strategies of Charm++. The general algorithm of this adaptive numerical method, utilization of the load balancing strategies as well as a set of numerical results will be discussed.

Adaptive finite element methods are widely used in computational fluid dynamics because of their reliability, robustness, and efficiency. During the adaptive computation process, portions of the discretized domain are spatially refined or coarsened (h-refinement) and the solution polynomial order is also varied (p-refinement). This enables concentration of computational efforts in regions of the problem domain where the solution is more varying. In our adaptive discontinuous Galerkin scheme, a posteriori estimates of spatial errors are obtained from the computed numerical solution. These error estimates are used to update the computation order on local elements during each time step.

By applying the above adaptive computation process, the work load on each processing element will vary as the computation proceeds. This necessitates a fast and efficient dynamic load-balancing strategy. This is an important factor for the efficiency of adaptive numerical methods, especially for large scale parallel computations. All of this makes Charm++ an excellent choice for us to improve hardware utilization and efficiency in our project.

In the present work, we verify the accuracy and robustness of our adaptive discontinuous Galerkin method by a wide range of numerical experiments with analytical solutions. Moreover, performance comparisons and analyses with and without load balancers as well as different load balancing strategies will be discussed to demonstrate that the combination of our adaptive discontinuous Galerkin scheme and the implementation of load balancing strategies significantly reduces the total execution times and also yields a comparable accuracy.

In the future, we will combine the mesh and polynomial-order refinement to obtain an *hp*-adaptive discontinuous Galerkin method that would be capable of computing in real world physics processes. A set of performance tests with thousands of compute cores will be conducted to verify the scalability and efficiency of our project.