DESIGN AND IMPLEMENTATION OF A COMPUTATIONAL ENVIRONMENT FOR HIGH PERFORMANCE SCIENTIFIC COMPUTING

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This thesis have a three-fold aim. The first one regards the design and implementation of a multiphysics framework for high-performance scientific and engineering computing. The other two aims are built on top of the first one, and they regard the development and implementation of two software components for the simulation of Fluid Flow and Radiative Heat Transfer respectively. We organize the thesis in three parts, one for each aim.
The first aim is devoted to the development and implementation of a software platform on top of which it is possible to develop software application aimed to specific kind of 2D and 3D simulation. The keylines of this platform are: effectiveness, efficiency, flexibility and usability. Following these keylines simultaneously is a challenging task, it can be accomplished only by developing novel strategies for making the following three aspects sinergically work together: numerical methods, physical modeling, computer science.

The second aim is devoted to the development and implementation of a Fluid Flow solver able to deal with Euler and Laminar Navier-Stokes equations. It is able to perform 2D and 3D parallel computation on mixed unstructured meshes. We therefore have implemented an application on top of the multiphysics framework that is able to address the problem of simulate flow fields using the finite volume and discontinuous galerkin method.
The third aim is devoted to another application, that is, the computation of Radiative Heat Transfer. We accomplish this aim developing some novel metodologies, such as the development and parallel implementation of a particular Monte Carlo approach for computing radiative heat transfer, and a novel particle tracking algorithm for tracking particle-like entities accross mixed 2D or 3D unstructured meshes in parallel computation.