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Flow Field Simulation for Aerospace Applications using High Performance Parallel Systems

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Summary

During the last few years, High Performance Computing has become an important aspect of scientific research for understanding the intricate interplay of the fundamental physics. Aero-acoustics, Biomechanics, Weather Forecasting, Oil exploration, Hypersonic Flows, etc. are better analyzed with the help of HPC. The solution of Navier-Stokesa?T equations under different flow conditions is a compute intensive application and requires basic knowledge of homotopic transformations, grid generation and its proper distribution, mathematical modeling, numerical schemes, pre-and post-processing & visualization. The problem is more complex if the flow is at an angle of attack and at high altitude. It requires lot of numerical experimentation to provide best combination of various parameters. C-DAC has designed and developed various HPC systems (PARAM) with state-of-the-art processing nodes as well as attempting to solve near- real life situations. The peak computing power ranges from 1 GFLOPS to 20TFLOPS. Many fluid mechanic problems were solved using these systems like, shock induced flow separation, shock reflections, flow profiles in the clean room, vortex induced oscillations, Direct Numerical Simulation for separated flow past a sphere, flow simulation near wing-fuselage junction and 3-D flow structure around surface mounted obstacles. The computations for hypersonic flow around re-entry type vehicles at high altitude were carried out for surface pressure / temperature distribution, skin friction / Heat transfer (catalytic / non catalytic wall) distribution. The gas dynamic equations for multi-components, multi-temperature, chemically reacting, relaxing gas mixtures, which consist of both neutral and charged particles were the mathematical basis for the study of hypersonic aerodynamics and heat transfer when dissipative, thermodynamics and chemical processes are present. This unsteady, three-dimensional problem dividing on coprocessors is considered as connection of unsteady 2-D problem interacting with each other and solved on PARAM using all its processors. The inter processor communications were through PARAMNeT. The different computational strategies targeting adequate flow resolutions were performed. In this presentation, the efforts to solve the Navier-Stokesa?T equations for wide range of applications using parallel systems are demonstrated. A few applications related to weather forecasting, air pollution and environmental assessment are also discussed. The capabilities of different numerical scheme on the parallel system are also benchmarked.