Annual Report for NCC5-613: A C++ Framework for Block-Structured Adaptive Mesh Refinement Methods

April 21, 2003

This report covers the period from 5/2002 to 9/2002.

Objective

The objective of this work is to develop a software framework for implementing block-structured AMR algorithms, based on the Chombo C++ framework for AMR applications developed at at LBNL. This framework includes support for the applications of multiphase flow in microgravity environments and star formation, and a visualization and data analysis toolkit.

Approach

The design approach is based on two ideas. The first is that the mathematical structure of the algorithms maps naturally into a combination of data structures and operations on those data structures which are embodied in C++ classes. The second is that the mathematical structure of the algorithms can be naturally factored into a hierarchy of abstractions, leading to an analogous factorization of the framework into reusable components, or *layers*. Functionality within a layer results from a combination of generic proramming and sub-classing. For visualization and data analysis, this approach is combined with the use of Python and TKInter to provide a GUI and interpretive command-line interface for performing these tasks. Finally, all of the tools developed here will be built on top of widely-available software platforms: C++ and Fortran 77 compilers and the Python interpreter, MPI

for distributed-memory parallelism, HDF5 for parallel I/O, and the VTK visualization toolkit.

Scientific Accomplishments

There were no scientific accomplishments in the time period covered by this report.

Technology Accomplishments

1. Completion of the software engineering plan and related documentation required under Milestone B. Acceptance of Milestone B by NASA program management.

2. Completion of the baseline measurements and release of the adaptive mesh refinement code for solving the incompressible Navier-Stokes equations, as required under Milestone E. This release includes supporting software design and requirements documentation.

3. Completion of the port of ChomboVis from Tcl to Python. This version (ChomboVis version 3) is available on the ANAG website, and has been made available to Dr. Kevin Olson, our NASA point of contact for ChomboVis. An example of a pyChomboVis visualization of an AMR Navier-Stokes benchmark problem appears in Figure 1.

Status / Plans

During the next fiscal year, we will undertake the following activities.

We will write complete high-level algorithmic and API specifications for the AMR fluid dynamics codes that will be developed in support of the microgravity and star formation applications (Milestone H). We will perform preliminary implementations of the parts of that capability specified in Milestone I. We will also deliver the improved version of the AMR incompressible Navier-Stokes code as specified in Milestone F.

We will complete the various enhancements in ChomboVis described in milestones O1, O2, and O3. This includes documentation of the requirements derived from discussions with potential NASA users of the ChomboVis

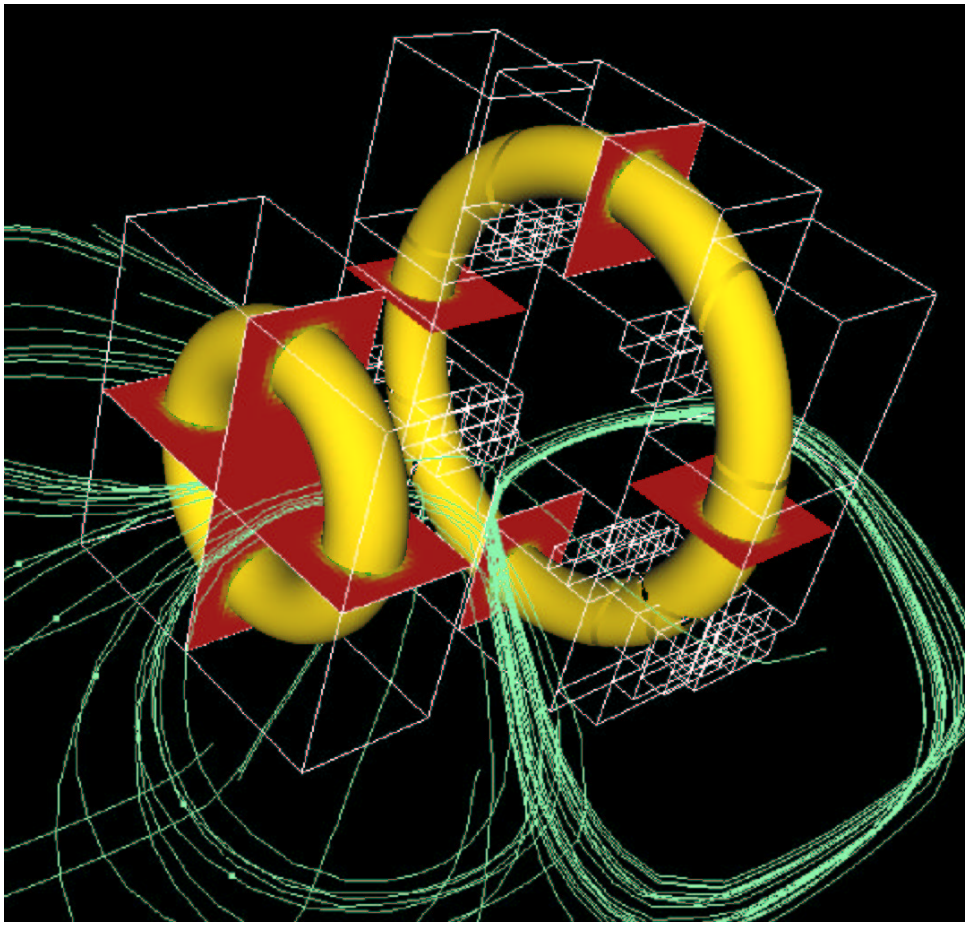

Figure 1: Visualization of a pair of co-rotating vortex rings, the benchmark problem for the AMR Navier-Stokes code, using the python version of ChomboVis.

software (Milestone O1-1), as well as user documentation (Milestone O2-4, O3-3); enhancements of the visualization capabilities (Milestones O2-2, O3-2); design and preliminary release of a data analysis capability (Milestones O2-1, O3-1); and a C / Fortran 77 I/O interface to the HDF5 parallel I/O to enable non-Chombo users to write ChomboVis-readable files from other block-structured AMR frameworks (Milestone O2-1).

Point of contact

Phillip Colella
50A-1148
Lawrence Berkeley National Laboratory
1 Cyclotron Road
Berkeley, CA 94720
PColella@lbl.gov

List of Publications

There were no publications during the period covered by this report

List of Conference Presentations

- Phillip Colella: Invited talk, Parallel CFD 2002, Kansai Science City, Nara, Japan, 5/20-22/2002.
- Daniel Martin: Invited talk, "Algorithm Refinement: Hybrid Numerical Schemes for Multiscale Applications", Los Alamos, NM, April 22-24, 2002.

List of Patents Filed

There were no patents filed during the period covered by this report.

List of Graduate Students or Postdocs Trained

There were no graduate students or post-docs trained during the period covered by this report.