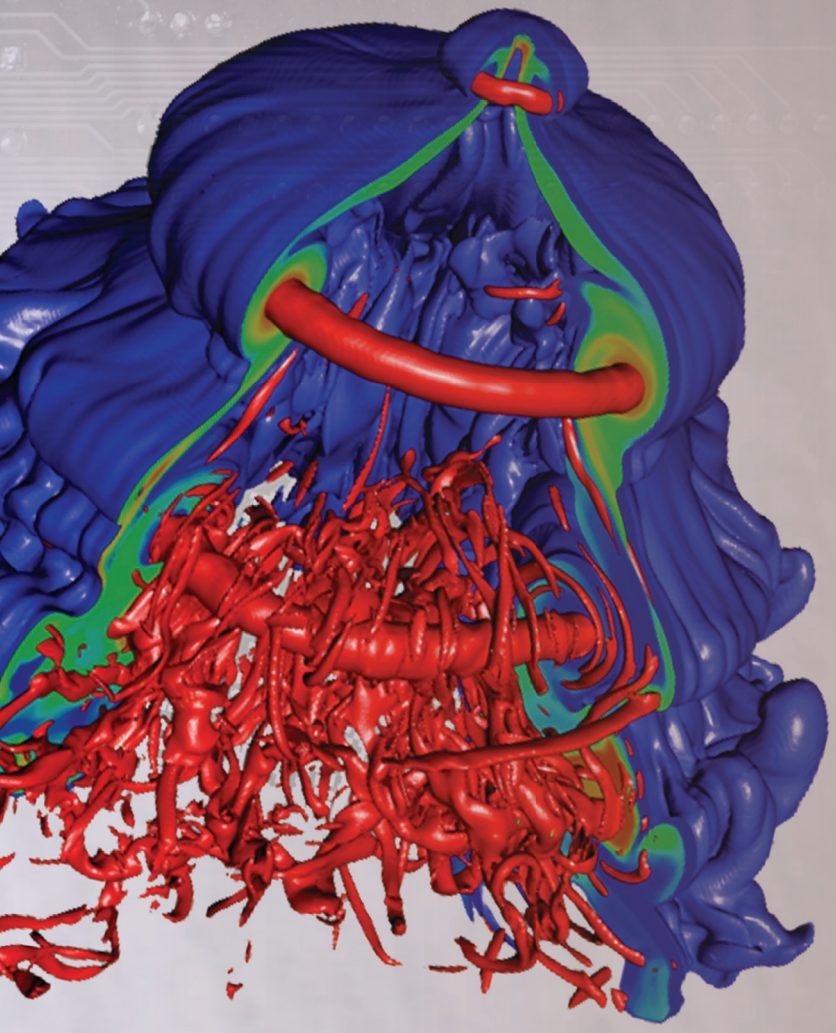
Picture Perfect with VisIt

COMPLEX simulations running on today's supercomputers can generate enormous data sets that contain trillions of bytes. To better understand these results, scientists and engineers often use visualization software to create pictures of the data that are far easier to interpret than reams of numbers. Problems that run for days or weeks on the world's most powerful supercomputers can now be visualized or analyzed in seconds using VisIt—a flexible visualization and analysis tool developed at Livermore.



With the visualization and graphics analysis tool called VisIt, scientists can create a three-dimensional image of a simulation. Here, results from a calculation using Livermore's RAPTOR code show the unstable growth of a dense spherical gas bubble subjected to a strong planar shock wave.

One of VisIt's strengths is that it has a scalable architecture, allowing it to process some of the biggest data sets ever generated. It also has a plug-in architecture, so additional capabilities can be easily added. VisIt is free as well, available as open-source software at: www.llnl.gov/visit.

VisIt is used to visualize data from a wide range of simulation codes including computational fluid dynamics, finite-element analysis, astrophysics, and hydrodynamics. The software was developed with funding from the Department of Energy's Advanced Simulation and Computing (ASC) Program by scientists in the Laboratory's Computation Directorate. The project team, led by computer scientist Eric Brugger, received a 2005 R&D 100 Award for this powerful application.

VisIt Is Flexible

Visual renditions of data sets range from the simple, such as basic plots, to the highly complex, such as three-dimensional (3D) volume renderings, with color frequently used to explain the data's characteristics. VisIt can produce images, movies, and statistical reports.

The visualization tool runs on various platforms from desktop computers to Livermore's Purple and Thunder supercomputers. Its three operating modes effectively use computing resources based on data-set size. For small- to medium-scale data sets, VisIt simply runs on a desktop machine. For larger scale sets, its work is distributed: Data are processed in parallel on a supercomputer, and surfaces are transferred back to a desktop machine for renderings. This mode leverages the best of both computing environments. On a supercomputer, large amounts of data are processed quickly through parallelization. The graphics card in a user's desktop computer provides the interactivity needed to examine data from different viewpoints. For the largest scale data sets, VisIt does all of the processing, including the rendering, on a supercomputer.

"Many visualization tools were originally implemented as serial applications that were later parallelized," says Brugger. "As a result, those tools cannot process certain algorithms, such as parallel streamline generation. We designed VisIt to be parallel from conception, so it's well suited for processing such visualization

algorithms and handling their communication and execution requirements."

Many Rich Features

VisIt supports different kinds of data input, and it can be easily extended through its dynamically loaded plug-ins. It also has a powerful graphical user interface. VisIt can be used to visualize different types of variables: scalars such as temperature or pressure, vectors such as velocity, and many more. It also supports 2D and 3D meshes whether they are structured, unstructured, adaptively refined, or gridless.

The software's plug-in design allows new capabilities to be quickly implemented. Database plug-ins import data from new file types. Operator plug-ins manipulate the data, for example, by slicing them or performing rigid body transformations such as rotation. Plot plug-ins define how data should be colored and rendered. VisIt even includes a tool for creating plug-ins. With it, a user describes a set of desired properties. The tool then generates most of the code needed to implement the plug-in.

The software's graphical user interface allows novice users to begin visualizing data quickly, while experienced users can access its advanced features. VisIt creates time-based animations from data sets with multiple time steps and allows users to pan, zoom, and rotate objects interactively using a mouse or other tracking device. Users can also easily size and position geometric objects such as planes and spheres.

VisIt is frequently used to debug simulation codes and has many features that allow code developers to access all portions of their simulations. In addition, its analysis capabilities include regression testing, where the output of computer simulations can be compared with their expected results.

Drop By for a VisIt

Brugger notes that VisIt has been downloaded more than 25,000 times by users from 4,000 different locations. Over 250 Livermore scientists use VisIt to render results from simulations of hydrodynamic instabilities, the dispersion of airborne chemical releases, and other complex physics events.

VisIt has enthusiasts throughout the world, including at the University of California at Berkeley, the San Diego Supercomputer Center, the United Kingdom's Atomic Weapons Establishment, and the Leiden Observatory of the Universiteit Leiden in the Netherlands. Jelle Ritzerveld from Leiden notes that, after trying several available visualization software tools, the observatory's astrophysics group not only uses VisIt but also recommends it to others. At Livermore, physics code group leader Michael Zika says, "I regularly use VisIt to gain insight into a wide range of physics simulations. It is an essential component of our scientific computing environment."

VisIt has already had an important impact on visualizing the extreme data sets in computational modeling and continues to broaden its user base. Says Brugger, "We're adding support for many new file formats and expect that, as a result, even more users will turn to it for visualizing data sets, constrained only by the disk space and computational resources available to them."

—Ann Parker

Members of the VisIt development team: (left to right, standing) Mark Miller, Sean Ahern, Eric Brugger, Kathleen Bonnell, and Brad Whitlock; (sitting) Hank Childs and Jeremy Meredith; and (kneeling) Linnea Cook.

Key Words: open-source software, R&D 100 Award, VisIt, visualization software.

For further information contact Eric Brugger at (925) 423-1293 (brugger1@llnl.gov).