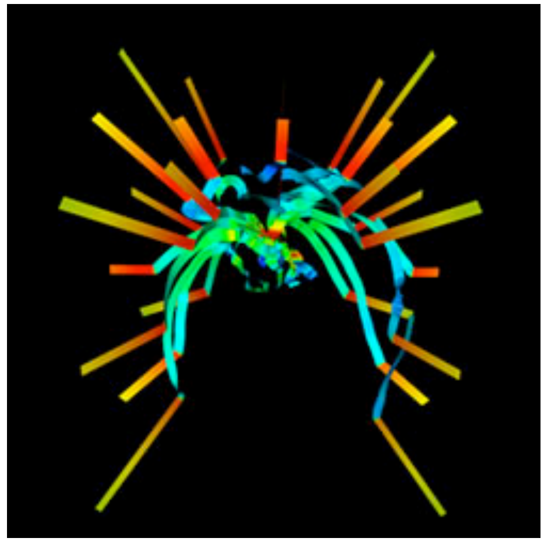
Parallel Computers, Advanced Visualization Drive N.C. State University's Supernova Research



When a star dies, the violent explosion releases protons, neutrons and all the elements necessary to sustain our universe. In essence, its death is responsible for our life.

Understanding this phenomenon, called a supernova, could open the door to major scientific breakthroughs in biology, energy, nuclear physics and the environment. But supernovas have baffled scientists for more than 40 years, mainly because of limitations in computing power.

That's why the Department of Energy's Scientific Discovery through Advanced Computing (SciDAC) program has contracted with North Carolina State and other universities to develop computer systems powerful enough to simulate and visualize a supernova explosion.

"Being able to replicate an explosion this violent will take computer technology on the terabyte scale," says John Blondin, a professor of astrophysics at N.C. State. "But it could lead to discoveries we never thought possible."

Thanks to recent developments in parallel computing and high-end visualization software, researchers are getting closer by the day to being able to simulate datasets that are a terabyte (1,000 million bytes) in size.

Hitting a Roadblock

"Supernova explosions have been studied using computers as long as computers have existed," Blondin says. "But because of the limited size of computers, these simulations were always done in one dimension. Now that computers are getting big enough we are able do 2D and 3D models. So simulating an explosion is now possible, but visualizing it is a different story."

Using an in-house compressible fluid dynamics code, N.C. State researchers were making progress running their 3D simulations on an IBM supercomputer with hundreds of processors. Then about a year ago, they hit a roadblock.

"All of the sudden our simulations were producing amounts of data so large that we didn't have the technology to look at it," Blondin says.

Parallel Power

It became obvious to Blondin and his team that the simulations would need to be viewed using a software program that can run on a parallel computing system in a multiple display environment.

"We can run the simulations on hundreds of processors," he says, "but the data produced by hundreds of processors all working together is much larger than the memory available in a single computer, so no one computer is large enough to visualize these large datasets."

Blondin went to conferences around the world searching for a software program that could view the data on a parallel computing system.

Visualizing Shock Waves

Blondin's answer was closer than he realized. CEI, based in nearby Apex, N.C., is the home of EnSight Gold, software that has been used to visualize datasets of a billion cells or more on parallel computing systems. EnSight Gold also provides built-in VR capabilities, which allows users to display results in a VR environment such as a CAVE. A CAVE not only enables greater amounts of data to be seen, it provides an interactive environment for manipulating very large models.

EnSight Gold plays a key role in DOE's Accelerated Strategic Computing Initiative (ASCI), a government-sponsored program for simulated nuclear testing. Two years ago, the software was used by Los Alamos National Labs to visualize a dataset containing 11.5 billion cells. This is believed to be the largest dataset ever visualized with commercial software.

The N.C. State team is starting small, but has plans to move rapidly into much larger datasets. Blondin's team has used EnSight Gold on a desktop Linux workstation to visualize shock waves created during a supernova explosion. The initial dataset consists of 33 million cells.

"So far I have used EnSight to show the flow of the explosion as it breaks out of the core of a star," Blondin says. "The flow comes in, hits a shock wave, and then gets redirected to create the explosion. Visualizing the flow lines have given us the first clue about how the star explodes."

But the dataset N.C. State wants to be able to see is a billion cells, larger than the workstation can handle.

CEI is now helping Blondin's team set up a Beowulf cluster, a rack of plain PCs tied together for supercomputing power. The cluster will help N.C. State simulate much larger datasets and visualize them using EnSight Gold in a CAVE.

"Once we are able to visualize that dataset, there will be others to follow that will be even larger," Blondin says. "The more we can see, the more we will discover about these explosions."

A Galaxy Not So Far Away

Because of the huge potential benefits of understanding phenomena such as supernovas, computational modeling and simulation has moved to the forefront of scientific research and discovery.

"Advances in computing technologies during the past decade have set the stage for a major step forward in modeling and simulation," the DOE says in a description of its SciDAC project. "Within the next five years, computers 1,000 times faster than those available to the scientific community today, i.e., terascale computers, will be at hand."

Once those computers are developed, there has to be software to run the problems and generate solutions. And, with datasets of that size, it is vital to be able to create visualizations that provide a better understanding of complex interactions.

Typically, computing power arrives years before the software to take full advantage of it makes the scene. N.C. State hopes that emerging new computing alternatives, along with EnSight Gold's continuing capacity to handle ever-larger datasets, will close that gap in record time, creating greater understanding of the now-mysterious supernova.

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