

## **LSU Team Wins First Prize at IEEE SCALE 2009 in Shanghai**

Cactus and a new distributed visualization system formed part of the winning entry from LSU to the Second IEEE International Scalable Computing Challenge (SCALE 2009), held at CCGrid09 in Shanghai, China. The LSU entry from researchers at the Center for Computation & Technology, or CCT, comprised a scalable, end-to-end, interactive system for the simulation and visualization of black holes.

In the context of numerical simulation, the entry addressed challenges (Fig 1) of programming productivity for complex science applications and scalability to large numbers of cores for accurate simulations and the efficient use of high-concurrency machines. The Mathematica-based Kranc package was used to generate Cactus thorns directly from the governing Einstein Equations, automating a process that would be highly time-consuming and error-prone when performed by hand. The resulting Cactus application, “McLachlan”, uses the Carpet Adaptive Mesh Refinement infrastructure to provide scalable, high order finite differencing, in this case running on 2048 cores of the Texas Advanced Computing Center (TACC) Ranger machine.

The simulation ran for altogether 160 hours on Ranger, generating 42 TByte of data. Live interaction with the simulation was shown, via an application-level monitoring, debugging, and profiling web interface (Fig 2). The simulation also used new thorns co-developed by an undergraduate student at LSU to announce runtime information to Twitter and real-time images of the gravitational field to Flickr (Fig 3).

Interactive visualization of the data produced was shown using a visualization system distributed across the Louisiana Optical Network Initiative, or LONI (Fig 4). A data server deployed on the Eric and Louie LONI clusters cached 20 Gb of data at any time in RAM using a total of 8 compute nodes. This data was then transferred using TCP and UDT protocols over the 10 Gbit/s LONI network to rendering nodes at a visualization cluster at LSU, with an average aggregate I/O rate of 4 Gbit/s. Here a new parallel renderer used GPU acceleration to render images, which were then streamed using the SAGE software from EVL to the final display (Fig 5). VNC was used instead of SAGE in Shanghai due to local network limitations. Tangible interaction devices (also located in Shanghai) provided interaction with the renderer.

The visualization system demonstrated its capability for interactive, collaborative and scalable visualization, achieving around 5 frames per second and an interaction time of less than 2 seconds. This achieved the team’s goal of showing how distributed systems can provide enhanced capabilities over local systems, in this demonstration the remote load time of 2 seconds was seven times faster than local I/O.

The LSU team (Fig 6) led by Prof. Gabrielle Allen, research scientist Andrei Hutanu and Research Prof. Erik Schnetter included research staff from the LSU Center for Computation & Technology, postdoctoral researchers, and graduate students Cornelius Toole, Kexi Liu from the Department of Computer Science, Oleg Korobkin from the Department of Physics and Astronomy as well as undergraduate Alex Clary from the Department of Electrical Engineering.

The work forming the SCALE09 demonstration was funded by the National Science Foundation (Alpaca #0721915, Blue Waters, Viz Tangibles #0521559, XiRel #0701566, Louisiana RII “CyberTools” #0701491) and the Center for Computation & Technology at LSU. The demonstration would not have been possible without the help of our colleagues at TACC and LONI.

### **LSU SCALE09 Team:**

*Cactus, Carpet and Numerical Relativity:* Erik Schnetter, Gabrielle Allen, Eloisa Bentivegna, Alex Clary, Peter Diener, Oleg Korobkin, Jian Tao.

*Distributed Visualization, Networks, Tangible Interaction:* Andrei Hutanu, Werner Benger, Jinghua Ge, Kexi Liu, Robert Kooima, Cornelius Toole.

*Computing, Logistics and Video:* Ravi Paruchuri, Jorge Ucan, Debra Waters, Sam White, Adam Yates.

### **More Information:**

#### *Demonstration Material:*

- SCALE09 link: <http://grid.sjtu.edu.cn/ccgrid2009/scale.html>
- LSU proposal: [http://preview.cactuscode.org/media/proposals/EAVIV\\_SCALE09.pdf](http://preview.cactuscode.org/media/proposals/EAVIV_SCALE09.pdf)
- LSU presentation video: <http://preview.cactuscode.org/media/videos/>
- LSU presentation slides: [http://preview.cactuscode.org/media/presentations/Scale2009\\_May2009.pdf](http://preview.cactuscode.org/media/presentations/Scale2009_May2009.pdf)

#### *Software:*

- Cactus Framework: <http://www.cactuscode.org>
- Carpet AMR Infrastructure: <http://www.carpetcode.org>
- MacLachlan Code: <http://www.cct.lsu.edu/~eschnett/McLachlan/>
- Kranc: <http://www.cct.lsu.edu/~eschnett/Kranc/>
- EVL SAGE Library: <http://www.evl.uic.edu/cavern/sage/>

#### *Projects:*

- NSF Louisiana RII (“CyberTools”): <http://www.cybertools.loni.org>
- NSF Alpaca: <http://www.cct.lsu.edu/~eschnett/Alpaca/>
- NSF Blue Waters: <http://www.ncsa.uiuc.edu/BlueWaters/>
- NSF Viz Tangibles: <http://tangviz.cct.lsu.edu/projects.html>
- NSF XiRel: <http://www.cct.lsu.edu/xirel>

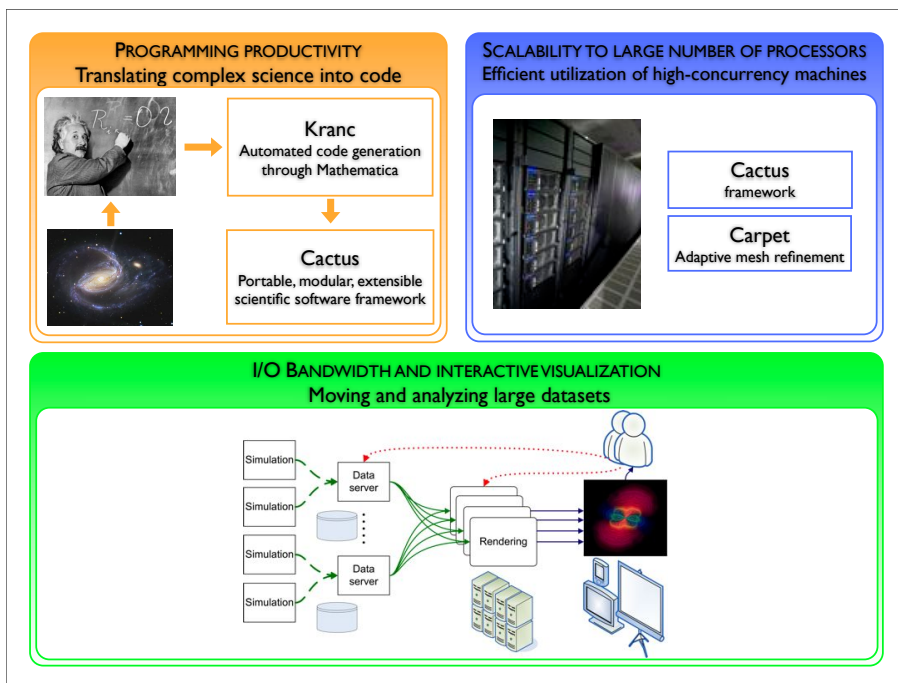


Figure 1: The system addresses four challenges for scalable computing for real world applications: (i) programming productivity, (ii) scalability to large numbers of processors, (iii) I/O bandwidth, (iv) interactive visualization.

**Simulation Home**

**Environment:**  
Time: 23:04:30 - 0500  
Date: May 14 2009 - 0500

**Simulation:**  
Generic Binary Black Holes  
scale09\_interp.par  
Iteration: 116325

**www.CactusCode.org**

**Generic Binary Black Holes**

This browser is connected to a Cactus simulation which server thorn. This thorn provides and control for the simulation.

ed into this simulation as user with monitoring privileges.

el Cactus job using 512 MPI processes and 4 threads per s.  
s 0 running on host i102-101.ranger.tacc.utexas.edu  
job ID: 718420  
d by user eschnett (Erik Schnetter)  
since start up  
2 hours  
25 minutes

Thursday, May 21, 2009

Figure 2: The Alpaca tools provide real-time access to simulations running on remote machines, allowing monitoring, interactive visualization, steering, and high-level debugging of large-scale simulations.

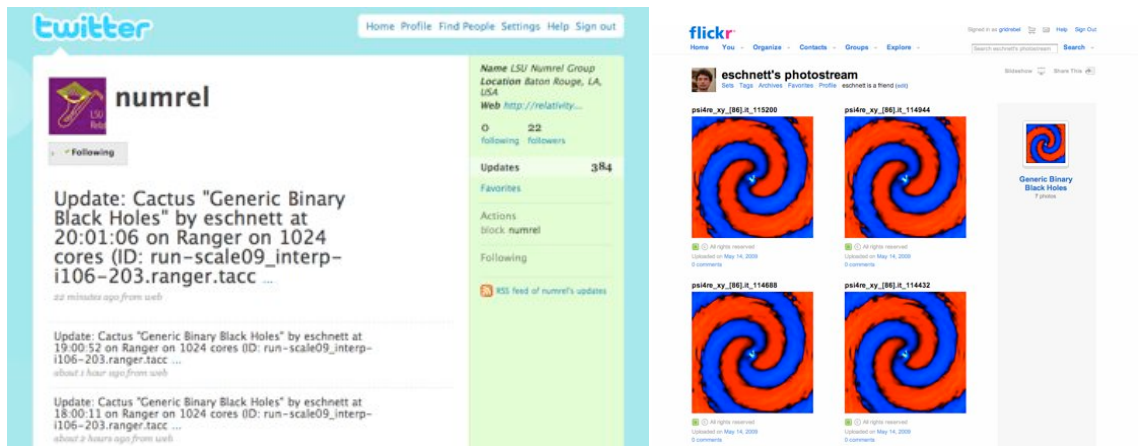


Figure 3: New Cactus thorns allow simulations to announce live information and images to (a) Twitter, (b) Flickr enabling a new mode of scientific collaboration using Web 2.0 technologies.

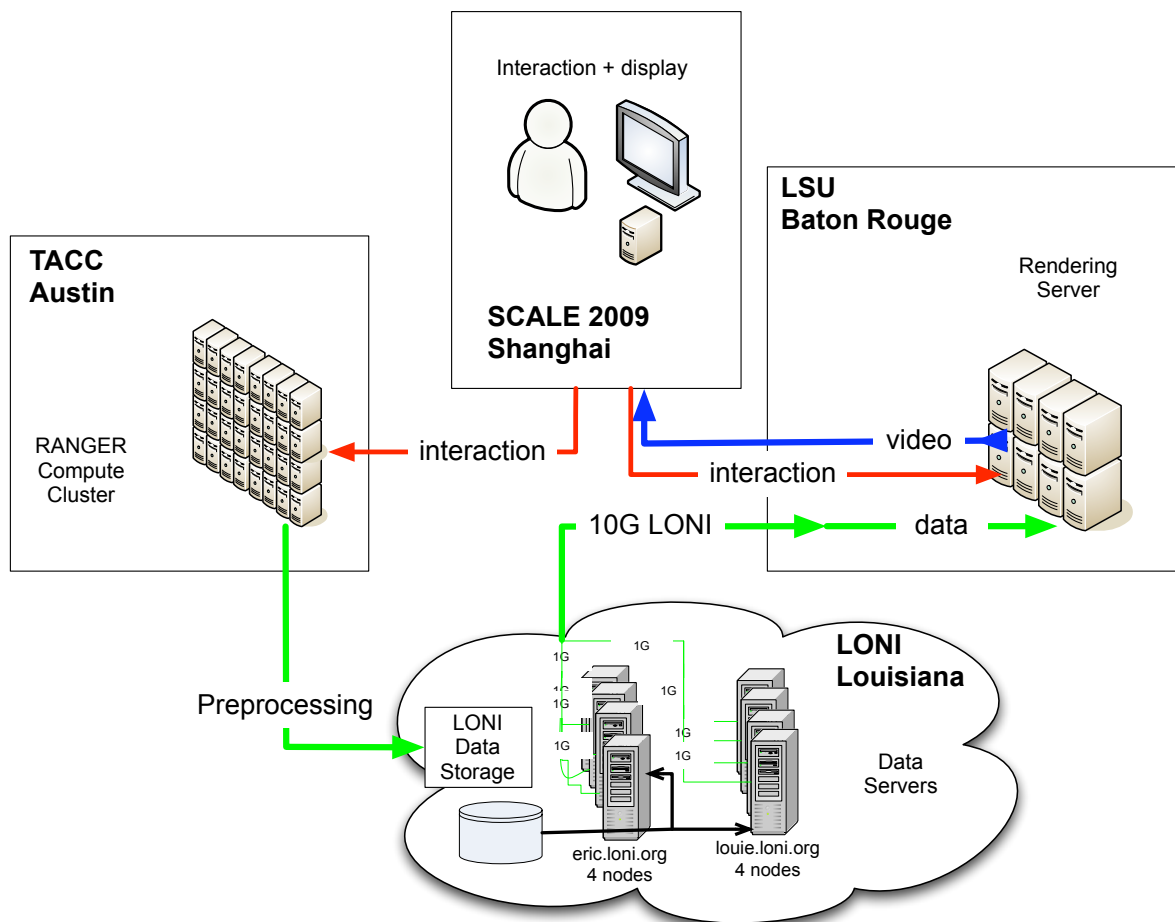


Figure 4: Set up of the SCALE09 demonstration that involved the resources of the NSF TeraGrid, the Louisiana Optical Network Initiative (LONI) and the Center for Computation & Technology.

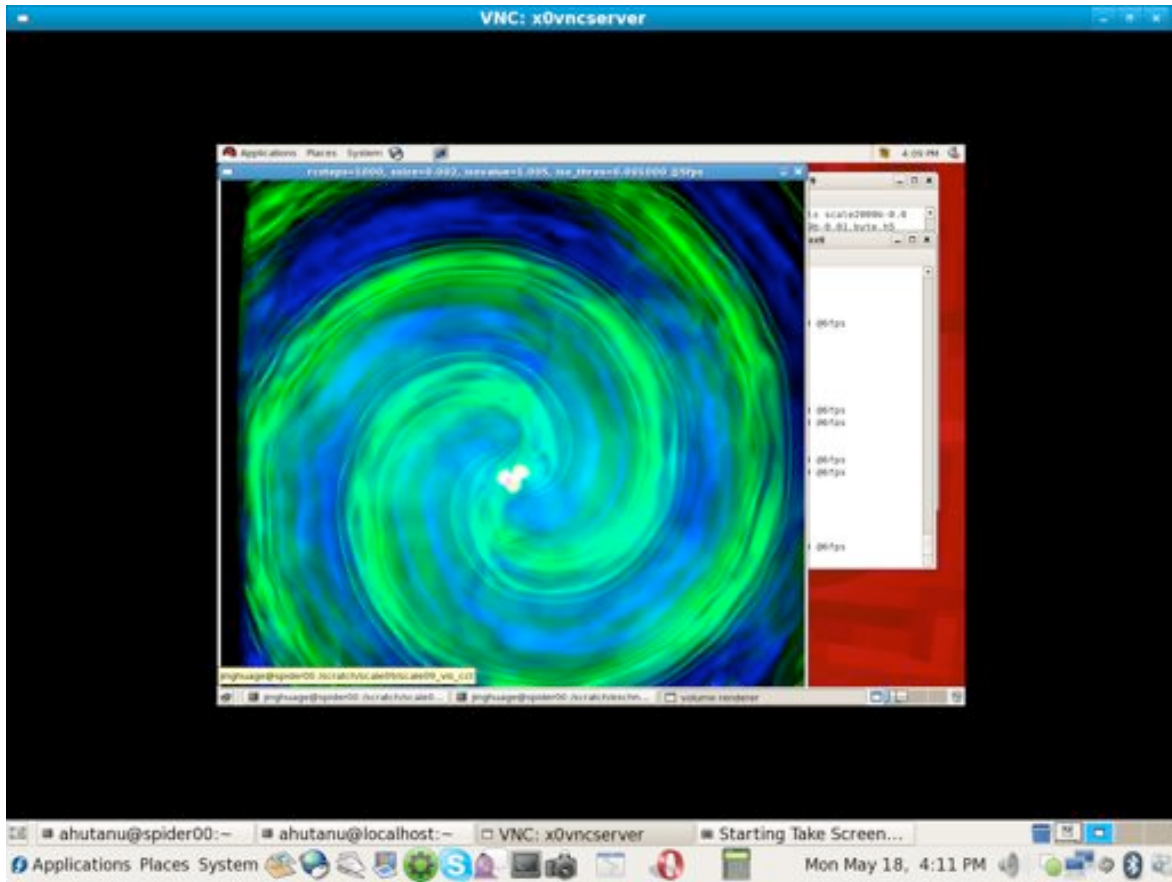


Figure 5: Visualization client on the end display showing rendering of gravitational waves emitted from the inspiral collision of two black holes.

May 21<sup>st</sup> 2009



Figure 6: The LSU SCALE09 Team: Left to right, (top) Gabrielle, Andrei, Jinghua, Ravi, Eloisa, Debra, Jorge, Jian, Erik, Werner, (bottom left) Oleg, Cornelius, (bottom right) Peter, Alex.