

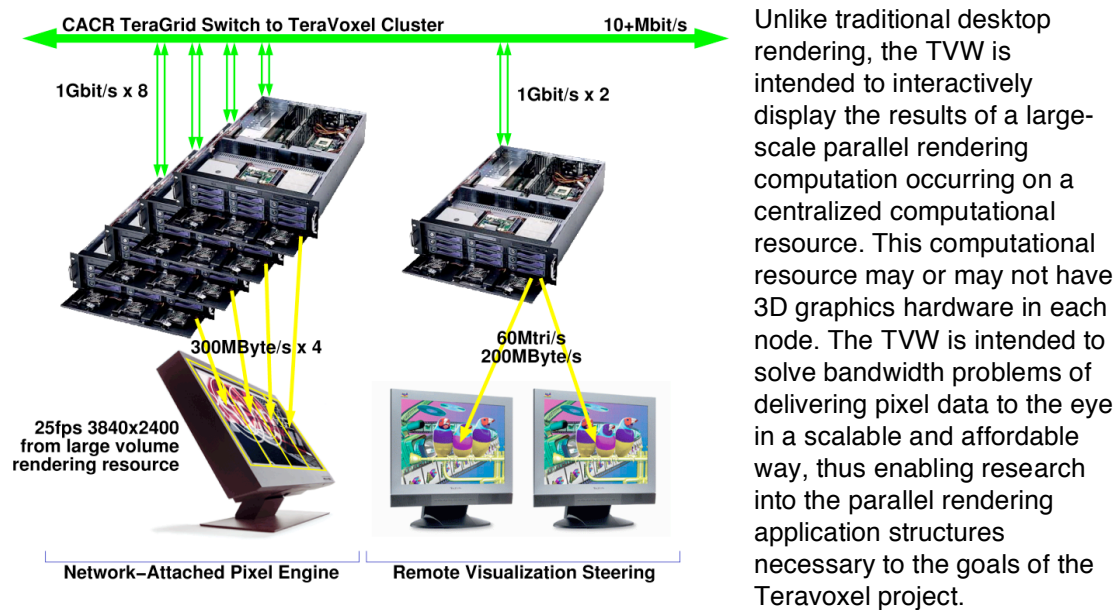
**Visualization**

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The visualization work done as part of the Teravoxel infrastructure can be mostly classified as pure hardware configurations or as software/hardware visualization development.

**Hardware Infrastructure**

The ability to interactively visualize volume datasets of unprecedented scale is central to the success of the Teravoxel effort. We have constructed a single-user cluster called the *Terascale Visualization Workstation (TVW)* which achieves the scalability and resolution of a multiprojector display wall in a desk-side form factor.



The cluster consists of five nodes, each of which is a 2-processor AMD AthlonMP 2100+ on an AMD 760MPX system chipset. Each node has 4 GByte of RAM and 1.3 TByte of disk. The cluster occupies a small rack which is the same height as the average desk and has been equipped with low-noise fans for a stealthy lab presence.

Four of the nodes drive four sections of an IBM T221 ("Bertha") display, which provides 3840x2400 resolution at over 200dpi. Two gigabit ethernet pipes and a high-performance AGP graphics coprocessor deliver an observed data bandwidth from network to screen of 950 MByte/s, corresponding to 25 frames per second at 4 bytes per pixel. The disks on these nodes are organized as a hardware-accelerated RAID-0 optimized for recording interactive rendering sessions for later reuse. These four nodes' collective 5.2 TByte disk array can record up to four hours of rendering session.

The remaining node is a traditional high-end graphics PC driving two high-contrast 1600x1200 fast LCD displays and providing the user's keyboard and mouse. Traditional GUI interaction with computation and rendering happens here, with results displayed on bertha. Additionally, this machine has a high-end 3D graphics coprocessor for traditional non-parallel visualization tasks.

Bertha delivers pixel density at the limits of visual acuity. The twin steering displays provide high contrast and outstanding response time (25ms) for crisp motion. Sufficient real bandwidth is available from network to pixels to reduce large-scale parallel rendering to a problem of pure computation. These resources create a compelling and capable workstation for meeting Teravoxel visualization challenges.

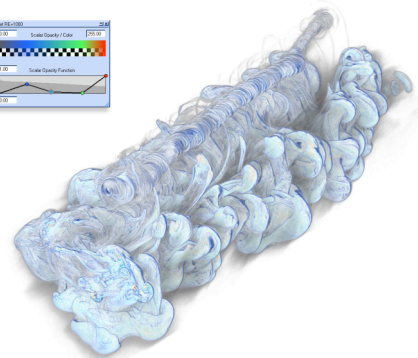
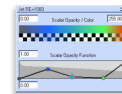
### *Software/Hardware Visualization*



On November 2001, at the SuperComputing conference in Dallas TX we demonstrated interactive volume rendering of a 512x512x512 12bit volume at frame rates of 24+ frames per second. This was done based on the implementation of an 8 node parallel volume rendering cluster equipped with specialized volume rendering hardware (VolumePro 500 by RTViz/TeraCon), as well as specialized dynamic image blending bus across the nodes; as presented at the Parallel Volume Graphics symposium in San Diego.

Our next iteration of this same cluster replaces the original volume rendering hardware with faster, more flexible, and more capable hardware (VolumePro 1000 by TeraCon). With this new implementation we should be able to render a 1024x512x512 volume at interactive framerates, or do multiple-field volume rendering of a 512x512x512 volume.

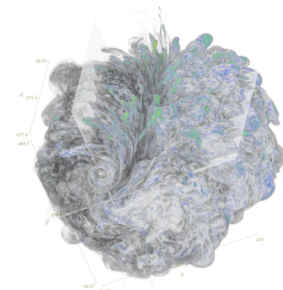
Similarly, in collaboration with Compaq-HP/Tandem we are investigating the use of commercial off-the-shelf graphic accelerator cards (e.g. Radeon 9700) to implement texture based volume rendering replacing the specialized hardware, resulting in images which can then directly be transferred from the graphics card to the pixel bus via DVI interconnect.



Once the cluster is deemed to be perfectly stable under one or several configurations the efforts will shift towards creating a remote interface which will allow users to log in remotely, transfer in data (parallel delivery as sub-volumes to each of the nodes), and the use the available visualization resources from their desktop.

Similar delivery of images will also be implement in the context of the transfer and distribution of high resolution images (3840x2400 pixels) to a parallel display (T-221, as explained above).

A parallel effort taking place at Caltech is focusing on the integration of a parallel systems framework, from a visual programming paradigm. As this endeavor takes shape, it will be



possible to encompass many of these operations from acquisition all the way to visualization from a dynamic human-understandable visual paradigm.

***REFERENCES:***

“Scalable Interactive Volume Rendering Using Off-the-Shelf Components” at PVG 2001

<http://www.cacr.caltech.edu/projects/lviz/results/pvr/>

VolumePro by TeraRecon

[http://www.terarecon.com/products/vp\\_1000\\_1\\_prod.html](http://www.terarecon.com/products/vp_1000_1_prod.html)

T221 Display by IBM

<http://researchweb.watson.ibm.com/deepview/>

Sepia by Compaq-HP/Tandem Labs

<http://www.research.compaq.com/SRC/pamette/>