LambdaVision and SAGE - Harnessing 100 Megapixels

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We envision situation-rooms and research laboratories in which all the walls are made from seamless ultra-high-resolution displays fed by data streamed over ultra-high-speed networks, from distantly located visualization and storage servers, allowing local and distributed groups of researchers to work together on large amounts of distributed heterogeneous datasets [1]. From working with our collaborators at the US Geological Survey and the National Center for Microscopy and Imaging Research we have seen how high resolution displays can be used to show detail and context simultaneously. From our prior work on the Continuum [2], we have learned that it is crucial for collaborators to have both local control (e.g. on a tablet or laptop) and the casual ability to share their work and see what others are working on (e.g. on a large tile display). We are leveraging our recent work and taking the next steps toward this vision by building LambdaVision, an 11x5 tiled display with a total resolution of 100 megapixels, and developing SAGE - the Scalable Adaptive Graphics Environment (see Figure 1.)

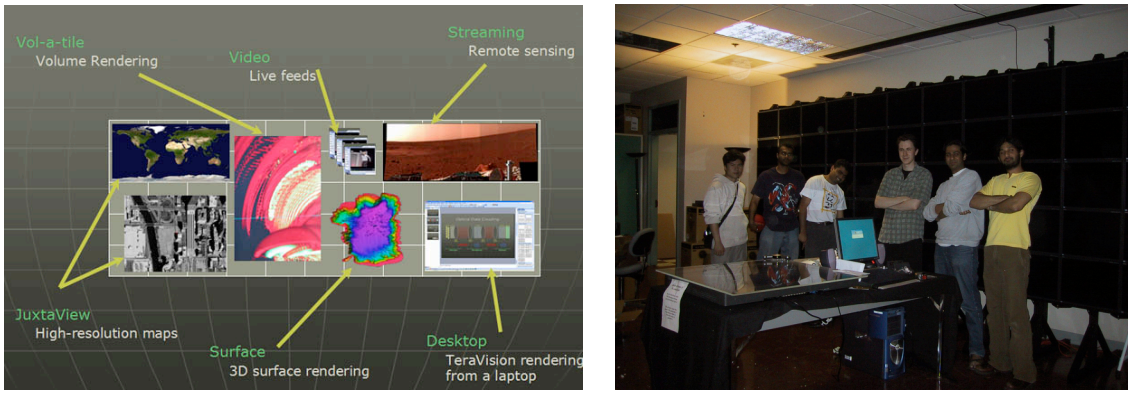

Figure 1: Example of a SAGE session (left) with multiple applications running simultaneously on the 55-tile *LambdaVision* display (right)

We have previously built a number of applications [3,4] for our 3x5 tile GeoWall-2 display (see Figure 2) where a group of users could work together using a single application taking up the entire display. SAGE allows us to run multiple applications, which can make better use of the larger *LambdaVision* display for data fusion activities.

The SAGE architecture consists of a number of rendering resources (from single desktop computers to clusters of local or distributed PCs capable of rendering graphics either with dedicated graphics hardware or software), connected over the network to a scalable frame buffer, in our case the *LambdaVision* display. Visualization jobs invoked by a user are automatically dispatched to the optimal visualization resource currently available on the network. The chosen resource performs the visualization and streams the resulting imagery for display. Note that, in some cases, it is more economical to render the visualization directly on the tiled display since the data is small enough to fit in the graphics cards' memory.

Figure 2: Several different applications running on the 5x3 GeoWall-2 display

Each application running in SAGE streams imagery using a highly optimized software library for lossless streaming of pixels over high-speed networks based on our prior work in high performance graphics digitization, and high-speed data streaming over gigabit networks [5]. This decoupling of the rendering process from the display allows SAGE to scalably support distance collaboration by streaming the pixels to all the participating endpoints using either traditional router-based multicasting or photonic multicasting. Different endpoints in the collaboration may be seeing the same visualization on different devices with different display characteristics.

The collaborators interact with SAGE's FreeSpace Manager (see Figure 3) that should provide an intuitive interface for moving visualizations around the tiled display. When a visualization window is moved from one portion of the screen to another, the FreeSpace Manager informs the remote rendering resource of the new destination for the streamed pixels, giving the user the illusion that they are working on one continuous computer screen, even though the systems performing the visualizations may be several thousand miles apart. The FreeSpace Manager is akin to a traditional desktop manager in a

windowing system except that it can scale from a single tablet PC screen to a desktop spanning 100 million pixels.

SAGE is designed to support data fusion for very large data sets. Collaborators at multiple remote sites with heterogeneous displays will be able to share and simultaneously visualize multiple datasets through SAGE. For instance, the users could be simultaneously viewing high-resolution aerial or satellite imagery, as well as volumetric information on earthquakes and ground water. Audio and video conferencing between the groups will be handled over the AccessGrid, where its streams are treated as another form of data that can be displayed on *LambdaVision*.

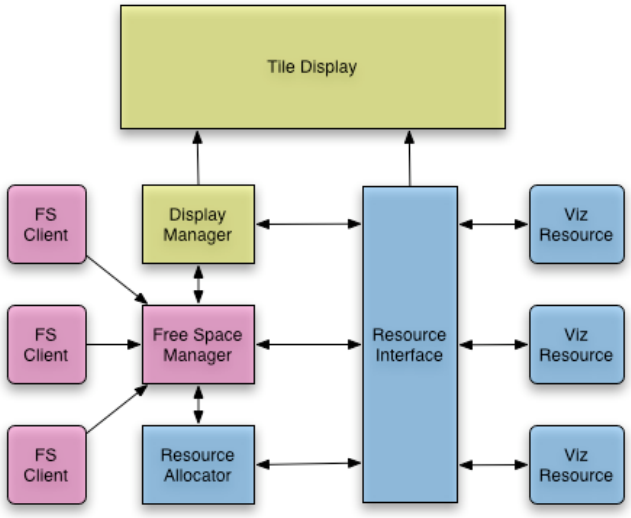

Figure 3: Components of SAGE

Users can control SAGE and the individual SAGE applications from tablet PCs, laptops, or more exotic interfaces such as the *LambdaTable* – imagine the 5x3 tile display shown in Figure 2 flipped onto its back with camera tracking. This decoupling of the user interface from the visualization allows users to easily share control of a given application between users at the same site or remote sites. Tablet PCs also give the users an easy ability to highlight and annotate information for the rest of the group. Our current prototype laptop interface for starting applications, sharing them with remote collaborators, and positioning them on *LambdaVision* is shown in Figure 4 and the interface for our high-resolution 2D image viewer JuxtaView is shown in Figure 5. We are also planning to investigate other interfaces such as using tracked tablet PCs as filters when held in front of *LambdaVision*, touch interfaces on *LambdaVision*, and physical icons on the *LambdaTable*.

1. Larry Smarr, Andrew Chien, Tom DeFanti, Jason Leigh, Philip Papadopoulos *"The OptIPuter"* Communications of the ACM, Vol. 46.11, November 2003, pp. 58-67.
2. Kyoung Park, Luc Renambot, Jason Leigh, and Andrew Johnson, *"The Impact of Display-rich Environments for Enhancing Task Parallelism and Group Awareness in Advanced Collaborative Environments"*, In the proceedings of the Workshop on Advanced Collaboration Environments, Seattle, WA, June 22-24, 2003.
3. Naveen Krishnaprasad, Venkatram Vishwanath, Shalini Venkataraman, Arun Rao,

Luc Renambot, Jason Leigh, Andrew Johnson, and Brian Davis *"JuxtaView – a Tool for Interactive Visualization of Large Imagery on Scalable Tiled Displays"*, In the proceedings of IEEE Cluster 2004, San Diego, CA, September 20-23, 2004.

4. Nicholas Schwarz, Shalini Venkataraman, Luc Renambot, Naveen Krishnaprasad, Venkatram Vishwanath, Jason Leigh, Andrew Johnson, Graham Kent, and Atul Nayak, *"Vol-a-Tile - a Tool for Interactive Exploration of Large Volumetric Data on Scalable Tiled Displays",* Poster at IEEE Visualization 2004, Austin, TX, October 2004.
5. Rajvikram Singh, Byungil Jeong, Luc Renambot, Andrew Johnson and Jason Leigh *"TeraVision: a Distributed, Scalable, High Resolution Graphics Streaming System"*, In the proceedings of IEEE Cluster 2004, San Diego, CA, September 20-23, 2004.

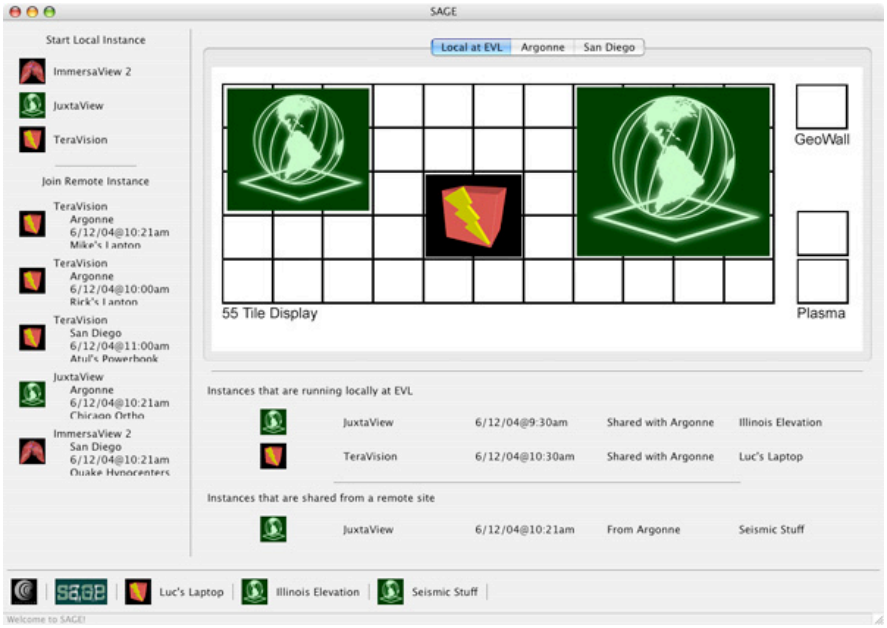

Figure 4: Prototype SAGE user interface to control the location and sharing of individual applications on LambdaVision and other local displays

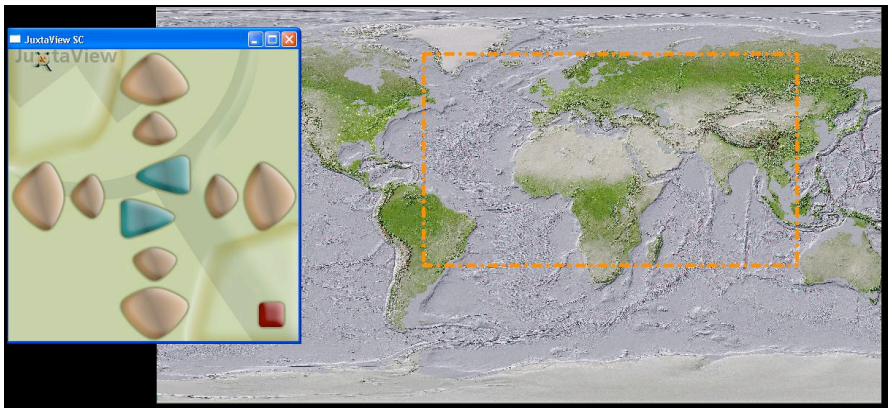

Figure 5: JuxtaView application user interface for zooming and panning through large 2D images running on a laptop to control the view on LambdaVision