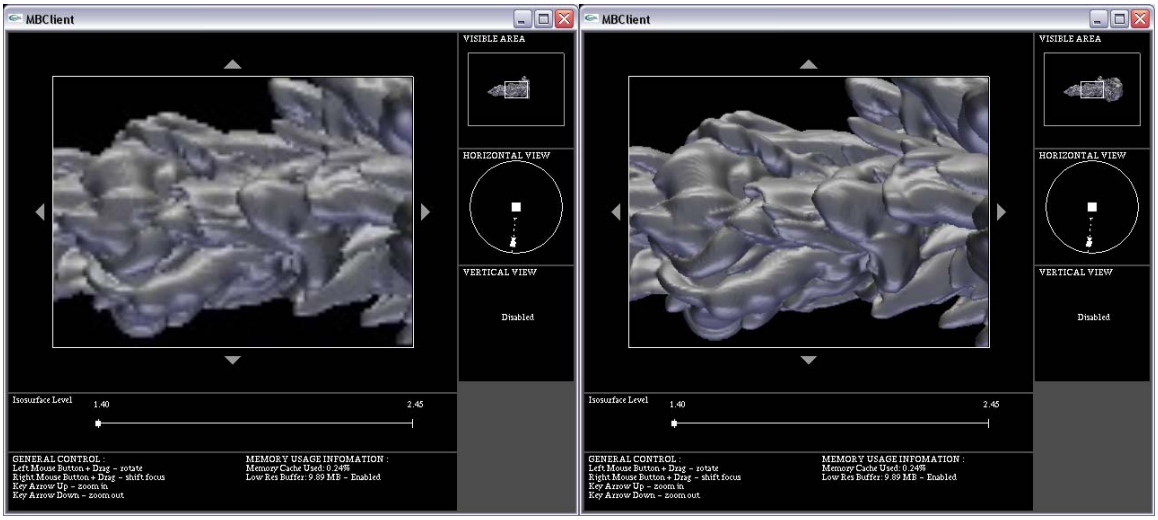
Interactive, Internet Delivery of Visualization via Structured, Prerendered Multiresolution Imagery

E. Wes Bethel[1], Ilmi Yoon[2], Jerry Chen[3]
[1]Lawrence Berkeley National Laboratory; [2]San Francisco State University; [3]Yahoo, Inc.

Summary

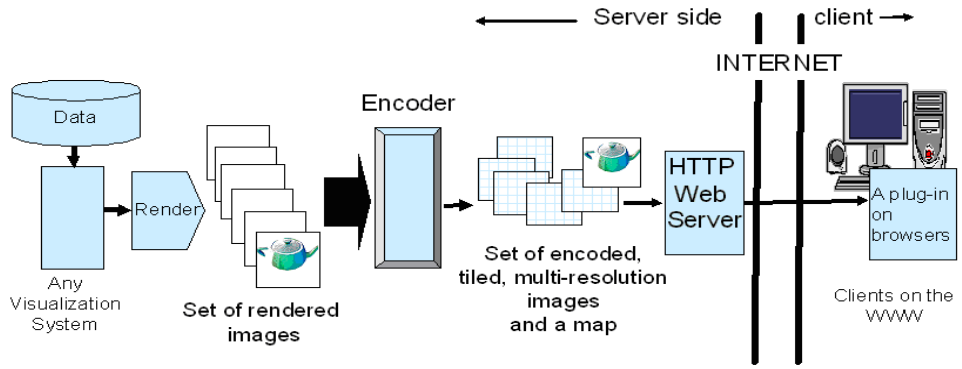
One of the fundamental problems in remote visualization – where I/O and data intensive visualization activities take place at a centrally located supercomputer center and resulting imagery is delivered to a remotely located user – is reduced interactivity resulting from the combination of high network latency and relatively low network bandwidth. This research project has produced a novel approach for latency-tolerant delivery of visualization and rendering results where client-side frame rate display performance is independent of source dataset size, image size, visualization technique or rendering complexity. As such, it is a suitable solution for remote visualization image delivery for any visualization or rendering application that can generate image frames in an ordered fashion. This new capability is suitable for use in addressing many of ASCR's remote visualization needs, particularly deployment at open computing facilities to provide remote visualization capabilities to teams of scientific researchers.



These two images are screen shots of the client displaying isosurface visualization image sequences at different zoom levels. In the left image, we have zoomed in up to the threshold where lower-resolution images are used as the source. The visual artifacts resulting from zooming in on low-resolution images are clearly visible. In the right image, we have zoomed in one more step -- just past the threshold where the client chooses the next higher-resolution images for display. This dynamic approach to multiresolution image selection and display approach is applicable to a broad range of potential application areas.

Typically, output from visualization and graphics applications consists of a set of images that result from changes in visualization and rendering parameters. Generally speaking, we can characterize the resulting image set as the exploration of visualization or rendering parameter space. Effective interactive remote visualization – where these images are transmitted over the network to remote users – is hampered by the combination of high network latency and low network bandwidth.

Our research has produced a novel approach for delivering visualization results – images – to



An end-to-end view of our image delivery implementation. First, a visualization application creates an ordered set images corresponding to prescribed changes in viewpoint, time, or other attribute suitable for remote client browsing. Next, a preprocessing step – shown here as "Encoder" – creates a "map file" and tiled versions of the images. A remote custom client contacts a normal web server, downloads the map file, then begins navigation through the ordered sequence of images. The client requests images through the web server as needed to satisfy a particular viewpoint, time step or other browsable attribute. This implementation is suitable for use with *any* visualization or rendering application that can generate images in an ordered fashion.

remote users. This approach is appropriate for many visualization and graphics use modalities. In particular, it provides what appears to the consumer to be an interactive data exploration experience in the form of semi-constrained navigation through visualization or rendering parameter space but without the cost associated with learning how to execute or use a potentially complex application on a remote computing platform. It is a general-purpose solution that is widely applicable to any application that produces visual output. It offers capabilities that overcome limitations of previous similar approaches making it suitable for use in delivering an interactive visual data exploration experience to a potentially large body of consumers.

The fundamental idea behind our approach is as follows. First, a rendering application generates a set of multiresolution images in a structured and ordered fashion, perhaps by varying the view position, one or more visualization parameters, temporal slice of data, and so forth. A collection of structured images might contain views of a 3D object where the viewpoint is moved along regular lines of latitude and longitude about the object. Second, a preprocessing step we refer to as "encoding" prepares the images for transmission to and consumption by the client. Third, a client application requests and displays the precomputed images at the user's pleasure.

The new contributions of this work are as follows. First, we employ multiresolution imagery and client side view-dependent resolution selection to overcome the fixed image resolution typically associated with digital media formats and user experiences. Second, our approach offers the ability to perform n−dimensional attribute browsing; in contrast, MPEG-1 and MPEG-2 offer one-dimensional browsing while QuickTime VR offers navigation through only three dimensions. Third, our implementation has a relatively small, fixed-size memory footprint making it suitable for use on a wide range of platforms. Fourth, we use a prefetching algorithm to minimize display latency and overlap I/O with display operations. Fifth, we conducted extensive performance studies: (1) evaluating the impact of tunable system parameters on storage requirements and end-to-end performance; and (2) reporting the performance improvement that result from prefetching, which effectively overlaps I/O and display processing

Publications

1. J. Chen, I. Yoon and E. W. Bethel. "Interactive, Internet Delivery of Visualization via Structured, Prerendered Multiresolution Imagery." *Accepted for publication, to appear in a 2008 issue of IEEE Transactions on Visualization and Computer Graphics.* LBNL-62252.
2. J. Chen, I. Yoon, E. W. Bethel. "Interactive, Internet Delivery of Scientific Visualization via Structured, Prerendered Imagery." In Proceedings of the 2006 SPIE/IS&T Conference on Electronic Imaging, Volume 6061, A 1-10, January 2006. LBNL-57528.

For further information on this subject contact:

Name: E. Wes Bethel.
Organization: Lawrence Berkeley National Laboratory.
Email: ewbethel@lbl.gov
Phone: (510) 486-7353

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