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STACKABLE MIDDLEWARE SERVICES FOR ADVANCED MULTIMEDIA APPLICATIONS

FINAL REPORT
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Introduction

This report summarizes the work that was conducted under DOE grant #:

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As part of the DOE Next Generation Internet program, the projects were to examine what networking technologies were required to support the visualization and networking needs of DOE applications. The original scope of our proposed work was to examine composable middleware services that could be used to created networked multimedia applications for DOE.

Due to funding cuts to DOE's budget, the NGI program was cut to one year. This meant that the projects were cut to two years (*but with only half the funds*). The rest of this report summarize the work conducted. We begin with the original scope of the work to give a broader vision of where we wanted to go. We follow this with what we accomplished and what results came out of this truncated effort.

The original scope of work

In this project, we propose the research, development, and distribution of a stackable component-based multimedia streaming protocol middleware service. The goals of this stackable middleware interface include:

- The middleware service will provide application writers and scientists easy to use interfaces that support their visualization needs.
- The middleware service will support a variety of image compression modes. Currently, many of the network adaptation protocols for video have been developed with DCT-based compression algorithms like H.261, MPEG-1, or MPEG-2 in mind. It is expected that with advanced scientific computing applications that the lossy compression of the image data will be unacceptable in certain instances. The middleware service will support several in-line lossless compression modes for error-sensitive scientific visualization data.
- The middleware service will support two different types of streaming video modes: one for interactive collaboration of scientists and a stored video streaming mode for viewing prerecorded animations. The use of two different streaming types will

allow the quality of the video delivered to the user to be maximized. Most importantly, this service will happen transparently to the user (with some basic controls exported to the user for domain specific tweaking).

In the spirit of layered network protocols (like ISO and TCP/IP), application writers should not have to know a large amount about lower level network details. Currently, many example video streaming players have their congestion management techniques tightly integrated into the video player itself and are, for the most part, "one-off" applications. As more networked multimedia and video applications are written in the future, a larger percentage of these programmers and scientist will most likely know little about the underlying networking layer. By providing a simple, powerful, and semi-transparent middleware layer, the successful completion of this project will help serve as a catalyst to support future video-based applications, particularly those of advanced scientific computing applications.

The result of our work

After hearing of the budget cut, we modified the scope of our program to examine the lossless compression issue as we felt that this would provide the most useful research to DOE with the shortened program. Unlike lossy DCT-based video compression algorithms that transform the data into the frequency domain so that it is more compressible (such as in MPEG and H.263), lossless image compression techniques attempt to predict the value of each pixel based on some of the surrounding pixels and then entropy encoding the difference to the predicted value. More importantly, it has been shown that there is little advantage to temporal compression of these sequences. Because of this, the compression ratios achieved by lossless image compression standards are much less than that of DCT-based algorithms. Yet, lossless compression is a requirement for many of the applications that DOE wants to deal with.

The efficient support for lossless video-based applications is extremely difficult because they require low-latency delivery of video while requiring much larger bandwidth, generally considered two mutually exclusive goals. In discussion with these researchers and scientists, two main themes manifested themselves. First, they need the ability to have low-latency visualizations so that they can understand what is happening in the simulation data at a higher layer (that is, general understanding). Second, they need the ability to query the data to be able to extract meaningful information from the data accurately.

One of the primary results of this work is that we have come up with a lossless video compression techniques that provides comparable performance to current lossless image compression techniques but is more amenable to network transmission. To accomplish this, we use a lossy compression algorithm to support the low-latency requirements and a lossless or loss-bounded differential file that allows the original data to be reconstructed. There are, however, one assumption that must be abided by. First, the same encoder and decoder software must be used. The architectures can be different, but the implementations of the decompression algorithm must be the same.

The results of this research were published in the following paper:

- Ali Saman Tosun, Amit Agarwal, Wu-chi Feng, "Providing Efficient Support for Lossless Video Transmission and Playback", in 10th International Workshop on Network and Operating Systems Support for Digital Audio and Video, Chapel Hill, North Carolina, June 2000.

We also have a journal version that is currently under review. We are currently working on making the lossless video code available (once appropriate licenses are put in place). The code will be placed at: http://www.cis.ohio-state.edu/~wuchi/DOENGI