Thin Client Performance for Remote 3-D Image Display

Albert Lai[1], Jason Nieh[2], Andrew Laine[3,4], Justin Starren[1,4]
Departments of [1]Biomedical Informatics, [2]Computer Science, [3]Biomedical Engineering, [4]Radiology
Columbia University, New York, NY

Background

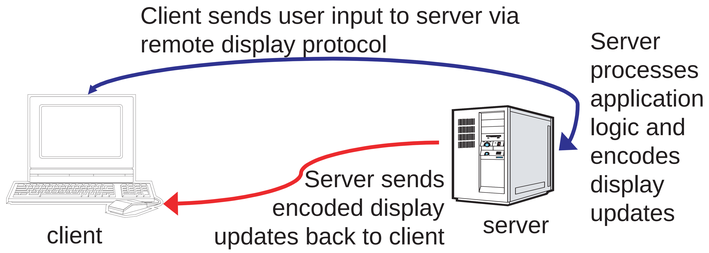
Several trends in biomedical computing are converging in a way that will require new approaches to telehealth image display. Image viewing is becoming an "anytime, anywhere" activity. In addition, organizations are beginning to recognize that healthcare providers are highly mobile and optimal care requires providing information wherever the provider and patient are. Thin client computing is one way to support image viewing in this complex environment. However little is known about the behavior of thin client systems in supporting image transfer in modern heterogeneous networks. Our results show that thin-clients can deliver acceptable performance over wireless networks if newer protocols optimized for these conditions are used.

Methods

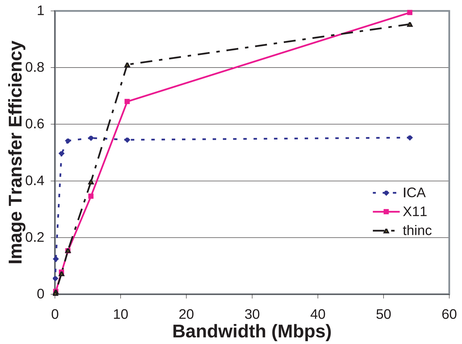
We employed slow-motion benchmarking to evaluate thin client performance. This method employs two techniques to obtain accurate measurements, monitoring client-side network activity and using slow-motion versions of application benchmarks.

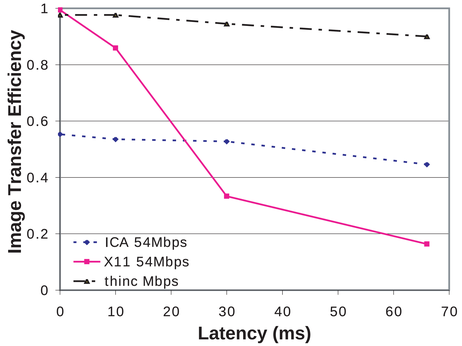
For the purposes of evaluating the performance of sequentially displaying slices using thin clients, we used an 85 slice, 128x128x24-bit SPECT imaging of the liver. We compared the performance of X, Citrix Metaframe (ICA), and our experimental protocol known as thinc. The platforms were compared across various network bandwidths and latencies that might be seen in wireless networks. All Platforms were tested at 24 bits per pixel to prevent any loss in visual fidelity, and 24 fps video speed. The platforms were compared in their performance across various network bandwidths and latencies that might be seen in wireless networks.

Thin Client Basics

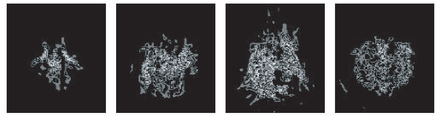


Thin Client Performance

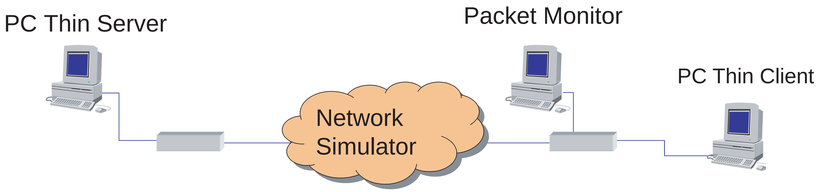




Effect of bandwidth and latency on cine display of SPECT images. The left graph shows the effect of bandwidth in a low-latency environment. The right graph shows the effect of latency when bandwidth is not limited. Data set is 85 slices, 128x128x24bit, displayed at 24fps.



4 representative slices of 128x128 SPECT imaging of liver



Results

The ICA protocol, which includes compression, performs best at low bandwidth. Both X11 and thinc perform better at high bandwidth. In evaluations of the effect of latency in a high-bandwidth environment, the ICA protocol shows moderate performance throughout the latency range. The X protocol is markedly affected by increased latency, while the thinc protocol (which is optimized for high bandwidth, high latency environments) performs significantly better.

Common Thin Client Platforms

Platforms	Primary Use
Citrix Metaframe (ICA)	Cross platform, low bandwidth, remote access
X11	UNIX workstations, Local Area Networks, low latency
thinc	experimental protocol, high bandwidth, high latency
Microsoft Terminal Services	remote access for Windows computers
Tarantella	Cross platform, changing network types
Virtual Network Computing	Open source, remote control of Windows computers

Discussion

Our measurements show that bandwidth availability is not always the main performance limitation and that designing for latency may be more appropriate. In addition, we show that thin-clients are a viable model for the delivery of 3-D medical data over wireless networks when using protocols designed for a high bandwidth, high latency, WAN architecture such as thinc.

Future Work

We plan to investigate the effects of intermittent connectivity on the performance of thin clients as well as develop thin client protocols to better handle intermittent connectivity that is seen in a mobile environment. Furthermore, we plan to investigate the use of thin clients for collaborative screen sharing.

Acknowledgements

This work was supported in part by a NSF grant CCR-0219943. Albert Lai is supported by a National Library of Medicine training grant NO1-LM07079.