High Definition Conferencing: Present, Past and Future

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***Abstract*— In this extended abstract we present the UltraGrid system, the current state of the art in high definition conferencing. UltraGrid was the first system to support gigabit rate high definition interactive video conferencing on commodity systems and networks. We review the design and implementation of UltraGrid, discuss experimental results and deployment, and conclude with our vision of the future of conferencing systems.**

I. Introduction

We review the design and architecture of UltraGrid [1], a high definition video conferencing and distribution system. UltraGrid is the first in a new breed of systems, capable of supporting uncompressed *high definition* video over IP, that has greatly evolved the state of the art in video conferencing systems compared to early research prototypes (e.g. [2]) and modern commercial offerings. Our goal in developing UltraGrid was to push the envelope in video conferencing capabilities and to demonstrate that modern end-systems and well engineered IP networks can support ultra high quality conferencing environments. To this end, UltraGrid provides low latency, uncompressed high definition video conferencing; high quality audio and large screen displays enhance the sense of presence, creating a realistic conferencing environment.

Using uncompressed high definition video impacts the user experience in several ways. First, the lack of compression allows the system to support very low latency, well below the 400 ms maximum recommend by the International Telecommunication Union (ITU) for interactive sessions, thereby enhancing the user experience. Secondly, the quality of HD images are superior in a number of ways: high picture resolution, lack of information loss due to lossy compression schemes, and a 20 bit color depth make for a richer image. These factors contribute to a video conferencing experience that supersedes other forms of conferencing.

II. Overview and Design

UltraGrid supports both standard and high definition (HD) interactive video conferencing, using readily available hardware. Both progressive ("720p") and interlaced ("1080i") HD video is supported. Video may be transmitted using an uncompressed format if network capacity is available (either at 1.2 Gbps for standard format HD video, or at 980 Mbps with an alternative HD format). In addition, a range of video codecs are supported to allow adaptation to lower rates at the expense of some increase in latency and reduction in quality. UltraGrid is typically used in conjunction with AccessGrid [3] to provide the complete conferencing experience shown in Figure 1.

In addition to interactive conferencing, UltraGrid can be used for general purpose HD distribution and visualization. The sender converts stored file content or live SMPTE 292M [4] high-definition video, as produced by professional cameras and production equipment, into an RTP packet stream for distribution across a variety of IP-based networks, and allows the receiver to exactly reconstruct the original signal. The design seeks to minimize latency, and allows UltraGrid to be used interactive data visualization and on-line video editing.

A major influence on the design of UltraGrid was to build a system that can be replicated by others with an objective of significantly evolving the quality of baseline interactive video conferencing systems. To this end, we built UltraGrid from commercial off the shelf components, make use of standard protocols and codecs (additional RTP Profiles and Payload Formats were developed and published through the standards process as needed [5–7]), and made our software available under an open source license to integrate with the AccessGrid and other Mbone tools. A more detailed description of our software design and hardware requirements is available in [8].

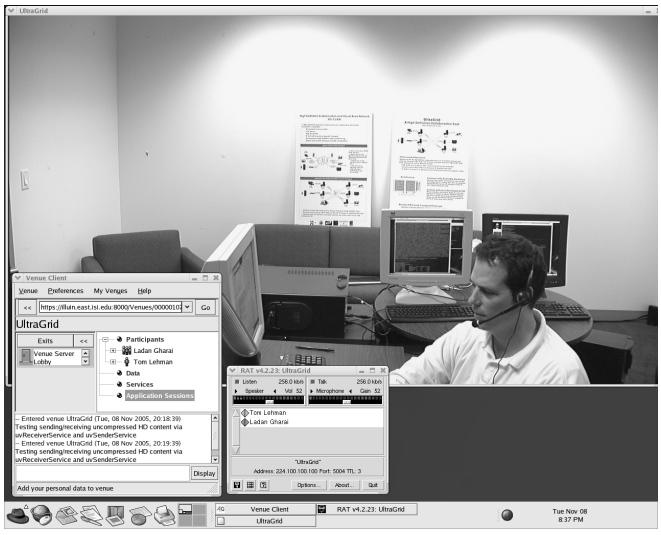


Fig. 1. Integration of UltraGrid and AccessGrid. In this example, UltraGrid is invoked by entering an "HD venue", advertised by the AccessGrid venue server.

III. Evaluation and Deployment

We conducted numerous local- and wide-area experiments to demonstrate correct operation of UltraGrid. Our initial local-area tests were conducted over the metropolitan area network from the DRAGON project [9] with favorable results. Currently (as seen in Figure 2) UltraGrid nodes are deployed at Mid Atlantic Crossroads (MAX [10]) offices at the University of Maryland, and daily UltraGrid conferencing sessions are used for collaboration between MAX and ISI-east.

Wide-area tests were conducted during the Super Computing 2005 conference. An interactive HD video conference was run between the conference exhibit floor in Seattle, WA, and ISI-east in Arlington, VA, for the duration of the conference (see Figure 3), running media flows over both the Internet2 Abilene best effort IP network and the Hybrid Optical Packet Infrastructure (HOPI) circuit switched path. Individuals at ISI-east were able to talk with participants at the conference via 720p format HD video. High quality low latency video, large displays and strategic positioning of cameras provided participants with an effective sense of presence.

During the conferencing sessions we monitored packet loss on both the Abilene HOPI and best effort IP paths. We did not observe any packet loss on the HOPI path, as expected from a dedicated provisioned optical backbone path. The best effort IP path over was generally loss free, but showed occasional packet loss up to 0.04% due to transient congestion on the shared path. These results demonstrate that both native, best effort, IP networks and hybrid IP/optical networks can be engineered to support even the most demanding real-time applications, such as high definition flows at gigabit rates.

IV. Conclusions and Future Directions

We expect high definition conferencing to become widespread in the coming decade: video quality has a great impact on a the user conferencing experience, driving the demand for HD conferencing. As our work demonstrates, current day end-systems and networks are capable of supporting real-time conferencing at gigabit rates. Additionally, with the continual reduction of cost in the hardware needed for HD conferencing, it will become more widely used, particularly in research or industry environments where the networking capacity and infrastructure is available.

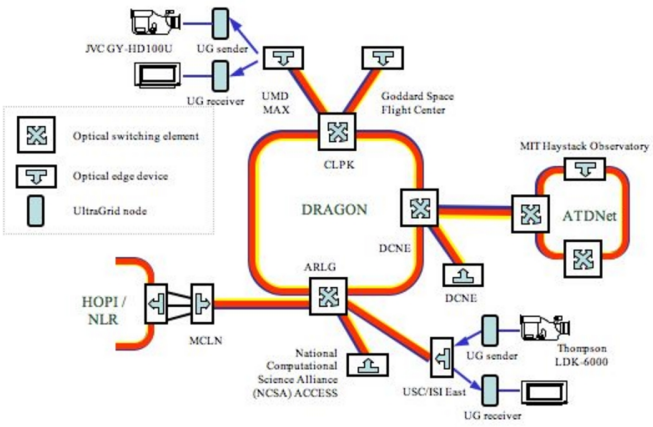


Fig. 2. Local deployment of UltraGrid nodes in the DC metropolitan area: MAX offices at University of Maryland, College Park, and ISI-east in Arlington.



Fig. 3. Super Computing 2005 UltraGrid demonstration.

V. Acknowledgments

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