TeraVision : a Platform and Software Independent Solution for Real Time Display Distribution in Advanced Collaborative Environments

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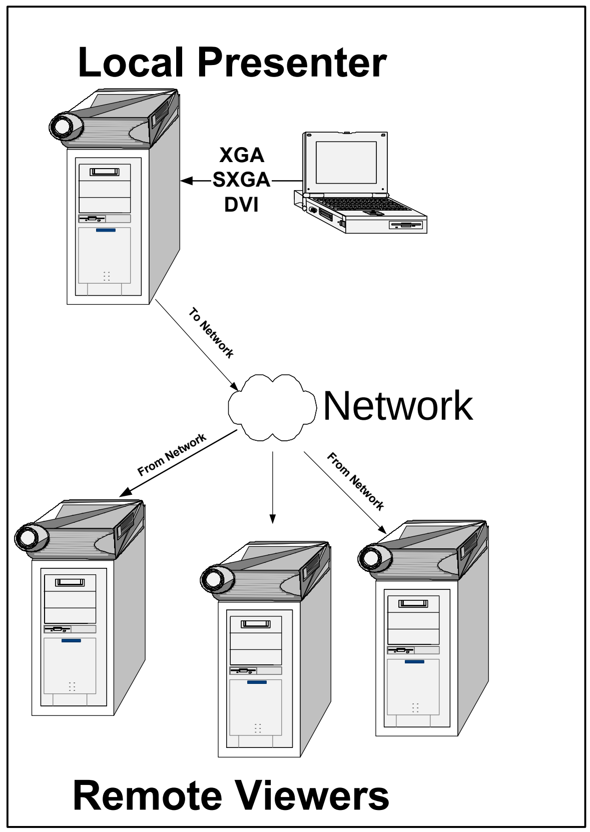
EVL's TeraVision is a real-time method to distribute visual imagery from any PC graphics platform over the Access Grid that requires no setup, software, or hardware changes to the user's computer. TeraVision's goal is to provide one solution for what is commonly referred to as the "Docking Problem / Display Pushing Problem" in Advanced Collaborative Environments such as the AccessGrid. That is, to provide a means for anyone on the Access Grid to plug-in, for example their laptop, and to deliver a presentation without having to install or configure any software, or distribute any of the data files, in advance.

One can envision TeraVision as a hardware-assisted, network-enabled "Powerpoint" projector for the AccessGrid. A user who wants to give a presentation on his/her laptop, or show output from one of the nodes of a graphics cluster simply plugs the VGA or DVI-output of the computer into the TeraVision Box (VBox). The box captures the signal at its native resolution, digitizes it and broadcasts it to other networked VBoxes (see Figure). Furthermore, using the VBox one can also transmit an entire tiled-display provided there are sufficient VBoxes at each end-point. Two VBoxes can be connected to the twin-heads of a stereoscopic AGAVE [1] system[Leigh2001a] to allow streaming of stereoscopic computer graphics.



The Hardware

The VBox prototype, consists of a DLP projector connected to a 1.5GHz Pentium 4 Windows PC with a Foresight I-RGB 75 high-speed frame grabber card and a Netgear GA620 Gigabit Ethernet (GigE) network interface card. The PC has both a 32 and 64bit PCI bus. The 32bit bus is used to support the I-RGB75, whereas the 64bit bus is used to support the GigE card. The graphics card on the PC is an ATI Radeon 8500 card.

The specifications of the I-RGB75 indicate that it is able to support up to a maximum input resolution of 1024x768 at 60Hz with sampling rates up to 75Mhz. We anticipate upgrading this to the new I-RGB 200 when it becomes available- which should be able to capture 1600x1200 at 75 Hz and 1280x1024 at 85 Hz. The bottleneck of course, is the available PCI bandwidth to transfer the captured image from the card to the graphics adapter or main memory. The specifications indicate a maximum sustained transfer rate of 120MB/s. 32-bit PCI's maximum theoretical bandwidth is 132MB/s. We anticipate that future frame buffer cards will support 64bit PCI as well as emerging bus standards such as 3GIO/PCI-3.

For the purposes of testing, the receiving end of the VBox is a Linux PC since our streaming software was originally developed for the Linux platform.

[1] AGAVE (Access Grid Augmented Virtual Environment) – A single dual-headed PC-based solution for rendering passive stereo computer graphics. Since its first prototype in January 2001, 12 sites in the Geosciences community have adopted it for undergraduate geoscience education and research. (www.evl.uic.edu/cavern/agave)

The Software

The prototype VBox software currently provides only point-to-point display sharing. In the case where multiple VBoxes are needed to display a stereoscopic image or a tiled-display, the VBox software will need to ensure synchronization in both image-capture at the source, and display at the destination.

Our TeraVision software was originally developed for the Linux platform and hence for the prototype, the capture portion of the software was ported to the Windows environment, while the display portion was left on the Linux environment. Since the TeraVision software was originally intended for streaming bitmaps for a tiled-display, it already has the capability to synchronize frame changes between transmission and display. This will make it possible in the future to connect a cluster of VBoxes to a tiled-display and stream the entire display, provided sufficient bandwidth is available.

For data transmission, we are currently using TCP but we have already developed a Reliable UDP protocol[Leigh2001b] that has been benchmarked to provide 500Mb/s throughput over a 622Mb/s link between Chicago and Amsterdam. Since we are currently only testing the VBox over a LAN we have not needed to use RUDP, however we anticipate that it will be needed when transmitting over networks with high bandwidth*delay products (e.g. StarLight [ST]).

Performance

We have tested the software in 3 stages- work is still underway to connect all 3 stages together for full end-to-end performance testing. In the first test, we determined the frame grabber's ability to capture a 1024x768 30Hz image from a laptop and display it on the Vbox's screen. The frame grabber's API provides direct memory access to DirectDraw's overlay buffer, and hence allowed the capture to occur at full frame rate with extremely low latency, without impacting the CPU at all. Secondly we performed a frame grabber-to-main-memory transfer- the pre-step to transferring the image over the GigE network card. We were able to achieve a maximum of 15 frames per second with a CPU load of 7%. Thirdly we tested our image streaming and display code between two Linux PCs connected over a GigE LAN, and was able to achieve approximately 29 frames per second while utilizing approximately 500Mb/s of network bandwidth.

Discussion

The main advantages of the VBox solution are that: a) it does not require modification of the host visualization software; b) it is compatible with any hardware that can provide a standard VGA or DVI signal; c) it scales to large tiled-displays providing there are sufficient VBoxes and bandwidth to support VBox streams; and d) image generation is decoupled from image capture and transmission- hence the host graphics system can operate at optimal frame rates.

The VBox will be demonstrated at IGrid 2002 (www.startap.net/starlight/igrid2002), in Amsterdam where a real time, immersive AGAVE visualization session will be streamed, in stereoscopic XGA resolution, from Chicago to Amsterdam over a 2.5Gb/s link. To achieve this, we are taking the left and right-eye VGA signals from the AGAVE's graphics adapter and plugging them into two separate VBoxes and streaming them to two receiving VBoxes in Amsterdam. The output of the receiving VBoxes will then be connected to powerpoint DLP projectors with polarizing filters on them to provide the audience a fused stereoscopic image. This serves as a canonical demonstration of how VBoxes can be ganged together to support tiled displays.

With the current generation of PCs, it is unlikely that it will have sufficient throughput to be able to stream the images to multiple sources at the same time, and quickly enough. What will be needed is a way to provide extremely high-speed reliable multicasting.

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