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IP-Based Video Modem Extender Requirements

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National Nuclear Security Administration (NNSA) Advanced Simulation and Computing (ASCI)

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1. Introduction

Visualization is one of the keys to understanding large complex data sets such as those generated by the large computing resources purchased and developed by the Advanced Simulation and Computing program (aka ASCI). In order to be convenient to researchers, visualization data must be distributed to offices and large complex visualization theaters. Currently, local distribution of the visual data is accomplished by distance limited modems and RGB switches that simply do not scale to hundreds of users across the local, metropolitan, and WAN distances without incurring large costs in fiber plant installation and maintenance. Wide Area application over the DOE Complex is infeasible using these limited distance RGB extenders. On the other hand, Internet Protocols (IP) over Ethernet is a scalable well-proven technology that can distribute large volumes of data over these distances.

Visual data has been distributed at lower resolutions over IP in industrial applications. This document describes requirements of the ASCI program in visual signal distribution for the purpose of identifying industrial partners willing to develop products to meet ASCI's needs.

1.1 Background

The U.S. commitment to ending underground nuclear testing, constraints on non-nuclear testing, and loss of production capability call for new means of verifying the safety, reliability, and performance of the U.S. nuclear stockpile. One of these means is computer-based modeling, simulation, and virtual prototyping of nuclear weapon systems. The ASCI program is one element of NNSA's Stockpile Stewardship Program (SSP) and is designed to advance NNSA's computational capabilities that are essential for maintaining the safety, reliability, and performance of the stockpile.

Visualization plays a key role in ASCI by giving researchers insight into the results of the simulations of the nuclear weapons components or systems. Typically, the results are stored in local storage systems, and then sent to visualization systems for rendering into graphical representations. However, the researcher who ran the simulation can be at any of the DOE ASCI facilities and may be remotely connected through either a MAN or WAN to the computing resource. Large data sets are sent over the WAN or MAN to storage systems local to the researcher, and rendered locally. Currently, the connection between the rendering resource and the actual display device is distance limited to only about a kilometer. To be convenient to the researchers, many rendering resources must be installed and maintained, *even locally*. This leads to high maintenance and installation costs if RGB fiber must be run to every office and rendering hardware, RGB switches, and other equipment must be installed in multiple locations.

1.2 Governmental Procurement Leverage for Development Efforts

Part of our mechanism for promoting this development is to provide a pre-product-release procurement to accelerate the development of technologies that ASCI has targeted as an urgent need. In addition, the Tri-Laboratory community offers our evaluation resources and provides a ready market.

1.3 Procurement Goal

The thrust of the effort described here is to accelerate the development of hardware for transporting analog and Digital Video Interface (DVI) signals. The modems are intended to take these signals as they originate from a rendering resource and transport them using the IP protocol over existing or new Ethernet installations. This IP networked approach, which is not distance limited, eliminates the need for multiple rendering resources, and extra fiber installation in offices by using the already available switching and fiber infrastructure. H.323 and other compression standards, as well as emerging standards for "Selective Refresh" of computer displays (e.g., VESA's DPVL) shall be utilized to reduce bandwidth demands.

The requirements described in the remainder of this document are grouped into two categories for each technical section: "Minimal Requirements," and "Desired Capabilities." The desired capabilities are simply those that exceed the minimal requirements and are included for the purpose of this market survey of vendor interest. The RFP contract will finalize the requirements into those that the "initial product" shall meet and those that the later, "advanced product" shall meet. The former are expected to include all of the minimal requirements described here plus, possibly, some of the desired capabilities that are deemed feasible by the vendor community. The advanced product requirements are expected to include all these plus many if not all of the desired capabilities.

The goal of this procurement is to obtain early delivery of a product that meets the initial product requirements, followed later by an enhanced product (or a separate product) that meets both the initial product requirements and also advanced product requirements. Gradual product enhancements over time might be another acceptable means of meeting the desired capabilities, although the initial procurement contract will precisely define these.

There is a need for both a "high-end" sender/receiver pair, tailored for high frame rates, high resolutions, and stereo graphics, and for an inexpensive "Low-End" version. Intermediate cost and function options may also be of interest. While these may simply correspond to the initial product and the enhanced product, the specific allocation of features in the low-end version might vary slightly from those specified for the initial product.

The inexpensive "low-end" version must be suitable for deployment in the many multi-tiled display walls, each with dozens of displays, and for hundreds of desktop users. The "low end" application is characterized by analog video and single link DVI cables, moderate resolutions, and moderate frame rates. The details are described in section 2, "Suggested ASCI Requirements for IP-Based Video Modem Extenders".

Please discuss how you would develop both a “low end”, “low cost” application product, and a “high end”, “higher cost” application product.

The minimal requirements describe a set of capabilities that the product must provide to be of any value to our applications. These requirements are also selected to be within the scope of well-defined and commonly accepted standards for handling analog and DVI video signals and network communication with simple form(s) of bandwidth conservation.

The desired capabilities include ones that push the state-of-the-art in video and display technology. They also include emerging standards and more complex bandwidth conservation algorithms. Vendors may choose to further subdivide these requirements if they find such to be more useful for product releases.

It is expected that the content of both the minimal requirements and the desired capabilities may be refined based on discussions with interested vendors so that the result is something that both meets the customer needs and is also considered feasible for the vendors to develop and support.

2 Suggested ASCI Requirements for IP-Based Video Modem Extenders

The following technical areas are presented as initial starting points for discussion and responses to this requirements document.

We envision the final product to function in pairs. One unit will accept both analog and DVI video from the rendering engine and also interface to Ethernet. For the purposes of this document we will call it the “sender”. Its primary purpose is to convert analog or DVI signals to IP packets and send them over Ethernet. It will also transmit keyboard, mouse and stereo synchronization signals. The other, “receiver” unit will connect to the CRT or LCD display at the user’s desk, or to a RAVE, CAVE or PowerWall display projector. Its purpose is to convert Ethernet IP packets back to analog or DVI, and provide keyboard, mouse and stereo synchronization signals. This document will also refer to senders/receivers collectively as “modems”.

Sender modems should accept both analog and DVI input signals and the receiver modems should output both signal types, regardless of what was input to the sender modem. Please discuss any unusual video formats that might not meet this specification.

The final installed system is likely to have more receivers than senders. This is because the number of senders will be determined by the number of rendering engines, while the number of receivers will be determined by the number of display modules in the RAVE’s, CAVE’s, PowerWalls, and in individual user’s offices. Each rendering engine and its connected sender may be connected through the IP network to different receivers at any one time, and may multicast to multiple receivers during collaborative sessions.

2.1 Resolution and frame rate

Minimal Requirements: Modems shall support most standard analog and DVI single link resolutions up to UXGA-W (1920x1200) at 75 Hz (analog) and for DVI up to the full DVI specification. Specifically, formats required to be supported are: VGA (640x480), SVGA (800x600), SXGA (1280x1024), UXGA (1600x1200), HDTV (1920x1080i & 1920x1200). Except as noted above, these shall be supported for analog frame rates of 60, 66, 72 and 75 Hz, and DVI up to full specification as listed in the current revision of the DDWG DVI spec.

For all analog video signals, the modems shall provide for automatic recognition of pixel clock rate and synchronize its A-to-D sampling to avoid aliasing.

DVI capabilities shall include management of control lines and standard frame rates consistent with the DVI 165 MHz maximum pixel clock rate per link.

Also, support for RGBHV, RG_sB and also RGBS shall be required.

Desired Capabilities: For analog signals, the modems shall also support resolutions up to UXGA-W (1920x1200) at 85 and 100 Hz and SXGA (1280x1024) at 85, 100, 105, 114, and 120 Hz. The modems shall also support HDTV (1920x1200). The receiver will be required to output refresh rates up to 180 Hz for certain lower resolution stereographic displays. Higher resolutions such as QUXGA (3840x2400) from single-link DVI shall be supported through mechanisms described in section 2.2, “Compression”.

The modems shall support analog and digital interfaces to the newer wide screen designations of WXGA (1280x768), QXGA (2048x1536), and digital interfaces up to QUXGA-W (3840x2400).

The modems shall support DVI connections with resolution of up to 3840x2400. See the IBM or Viewsonic, Inc., displays that are capable of such resolutions. Please describe how you would support these displays.

Where necessary to support higher resolutions and frame rates, the modems shall provide support for dual DVI-I, if an accepted standard exists. Any modification to the DVI spec that improves performance shall be supported.

Where analog video automatic pixel-clock recognition is used, the modems shall also permit custom analog and DVI configurations to be loaded via the control interface, and shall also permit overriding of this auto-recognition through the control interface.

Please comment on the feasibility of optionally accommodating different frame rates out of the receiver modem than those of the source video signal from the host. This feature might use the EDID information of the display as an aid to automatically selecting an appropriate frame rate in the receiver modem.

2.2 Compression

Compressibility will depend on the characteristics of the video images being processed. For the ASCI program these cover a wide range, including the following.

- Movies of 2D graphics: Solid colored, non-gradient geometric regions, unchanging surrounding background region of constant color, regions change size and location with time, rendered frame rates up to 30 Hz.
- Movies of 3D graphics: Very few regions of constant color, unchanging surrounding background region of constant color, rendered frame rates up to 30 Hz.
- Interactive 2D: Solid colored, non-gradient geometric regions, unchanging surrounding background region of constant color, rendered frames only on user action
- Interactive 3D graphic: Very few regions of constant color, unchanging surrounding background region of constant color, rendered frames only on user action
- Live and static camera video

To aid the vendor, sample movies, and movies of interactive sessions may be made available.

Minimal Requirements: Compression algorithms shall be provided and shall be capable of reducing the maximum data rates shown above (section 2.1, Resolution and frame rate) for compatibility with a 1 GigE connection using a lossless algorithm. Spatial, temporal or other lossless compression algorithms are acceptable. Dropping frames shall only be allowed for a particular video stream where a well designed lossless compression algorithm is incapable of delivery due to limitations in the throughput capacity of the network.

The receiver shall rescan its same frame buffer as necessary to maintain the display refresh rate required to eliminate flicker and conform to the display's input requirements.

The modem pairs shall provide user-accessible controls that will allow turning compression on or off and varying compression in order to eliminate visual artifacts of compression in the remote image.

Desired Capabilities: To provide even larger compression, the modems shall also implement lossy compression algorithms. These may include temporal (forward only), spatial, progressive rendering from lossy to lossless or other algorithms.

A desired feature of the modems would be to provide a mechanism for OS or application level dynamics performance hinting. This could be used to note screen regions of particular type of level of loss tolerance (e. g. this region is B/W text, 3D solid graphics, lines, display latency tolerant, etc.). Such information might be used by the modems to optimize or prioritize algorithms in the applications themselves. In general, the mechanism allows for dynamic changes in the transmission, via dynamic, programmatic interfaces.

The modems shall provide full controls over all relevant quality-of-service parameters:

- Select/enable/disable any compression scheme or schemes
- Select quality of lossy compression
- Select frequency of reference frames (if temporal compression makes use of these)
- Select minimum and maximum network delivered frame rates

- Select bandwidth utilization target
- Configure other parameters to provide the user necessary flexibility to maximize the use of available bandwidth to display the video information that is of most interest.

2.3 Latency

Minimal Requirements: Image latency attributable to the modems shall not exceed three host (source)-frame times, with lesser values available for a subset (e.g., simple run length encoding) of the compression options.

Suggestions for compression techniques that will reduce the bandwidth requirements and the latency are welcome. Of great interest are innovative "selective refresh" technologies such as the emerging VESA standard called "Digital Packet Video Link" (DPVL). Suggestions for, and discussions of, multiple compression algorithms with different loss characteristics and low latency are welcome.

2.4 Remote keyboard and mouse

Minimal Requirements: The modems shall support but not require transmission of keyboard and mouse signals over the Ethernet connection. The sender/receiver combination shall contribute no more than 50 msec of round trip latency to the keyboard command/response time.

The vendor is not responsible for any latency or jitter beyond that introduced by the modems.

2.5 Ethernet/ IP ports

Minimal Requirements: Modems shall provide one full-duplex 1 GigE Ethernet connection.

Desired Capabilities: Modems shall support 10 GigE jumbo-packet Ethernet connections.

The 10 GigE would be primarily used in cases when disabling compression is important or when high frame rates, extremely low latency, and large screen updates of high resolution are required.

ASCI experience with systems of this sort has uncovered the need to be able to throttle the compressed video throughput to the available network capacity so that packet congestion loss is minimized between sender and receiver. Comments on the connectivity-driven requirements for bandwidth management or reservation, switching infrastructure, etc., are welcome.

2.6 Switching between local computing resource and the rendering engine

Desired Capabilities: Since display costs can be high, particularly for high-resolution LCD displays, we require that the receiver be capable of switching between the user's local computer, and the remote rendering unit. The ability to view the actual local image at the sender unit is required.

2.7 Stereo capability

Minimal Requirements: The modems shall support active stereo for use with CAVEs, RAVEs, and PowerWalls, as well as with stereo desktop displays. Appropriate means shall be provided to ensure proper right/left frame synchronization. For the active stereo case, this requirement includes support for the stereo synchronization signal.

The modems shall support a final framing rate displayed on the screen of 90 - 120 Hz, for resolutions of SXGA and lower. The desktop displays often will be off the shelf CRTs from vendors that are capable of high refresh rates at high resolutions. Please discuss how you plan to keep frames synchronized.

Desired Capabilities: The modems shall also support passive stereo including appropriate synchronization for left-right image coordination at the display device.

The modems shall permit operation with two senders, one for use with left frames, and another used for right frames to be merged into a single receiver that is capable of synchronizing eyewear shutters to the appropriate frames. This requirement is in addition to that for a single sender modem processing both left and right frames in frame sequential manner.

2.8 External Frame Synchronization and Tiled Displays

Desired Capabilities: Tiled "PowerWall" displays are common in the ASCI environments. Such installations include active stereo as well, necessitating synchronization between tiles and the generation of stereo glasses signals for the entire aggregate display. The proposed modems should include a mechanism for providing synchronization between a collection of modems that are being used to drive such a tiled display (e.g. external genlock, etc.). Systems that can reduce tile "tearing" artifacts as well as supporting stereo synchronization are valued. The labs are particularly interested in solutions that can be cost-effectively deployed with as few as 2 tiles, but that can scale to 64 tiles or more. Any requirements the modems might place on the video sources should be clearly spelled out and discussed with tri-lab personnel.

2.9 Software Receiver

Desired Capabilities: A software tool or library shall be provided for use in place of the receiver modem. For lower performance applications that can tolerate greater latency and/or lower frame update rates, a software-based receiver operating on a desktop computing platform will provide reduced cost desktop visualization and will also provide a readily deployable tool for debug/diagnosis of sender operation. It shall operate on Linux, Windows 2000 and XP, and Macintosh OS X platforms. The modems are permitted to make use of capabilities present on nVidia cards.

2.10 Collaborations

Desired Capabilities: The intent is to allow sharing of a sender, utilizing Ethernet multicast, to multiple receivers. Please discuss how you would accomplish this type of collaboration and in particular in a switched environment. Also discuss how authentication would be accomplished.

2.11 Authentication and Need-to-Know

Minimal Requirements: In a switched environment, it is necessary to prevent a user who has no need-to-know from connecting the receiver to an unauthorized sender. This can be thought of as configuring modems as unique sender and receiver pairs, so receiver modems only process data from their matching sender. Configuration of sender/receiver pairs can be done on either or both "ends" with the following restrictions (where "sender" means the modem connected to the video source).

- If the configuration of the sender is done by serial interface, access to the configuration controls needs to be protected by a changeable alphanumeric password of at least eight characters.
- If the configuration of the sender is done via "private" Ethernet connection (meaning an interface different than the one used for sending/receiving the KVM data), then access must be protected by a changeable alphanumeric password of at least eight characters in length. It is also desirable, though not absolutely necessary, to provide encryption using a standardized transport layer encryption protocol (e.g. SSL, TLS, ssh, etc.)
- If the configuration of the sender is done via the same Ethernet interface as used for KVM transmission, then access must be protected by a changeable alphanumeric password of at least eight characters in length and the configuration login and interactions must be encrypted using a standardized transport layer encryption protocol.
- If the configuration of the receiver is done by serial interface, access to the configuration controls need to be protected by a changeable alphanumeric password of at least eight characters.
- If the configuration of the receiver is done via "private" Ethernet interface, then access must be protected by a changeable alphanumeric password of at least eight characters in length and the configurations login interactions must be encrypted using a standardized transport layer encryption protocol.
- If the configuration of the receiver is done using the same Ethernet connection as the KVM transmission, then access must be protected by a changeable alphanumeric password of at least eight characters in length and the configuration

login and interactions must be encrypted using a standardized transport layer encryption protocol.

- If the configuration of the sender or receiver is done via switches, jumpers, or other mechanical settings the mechanism must be internally mounted.

If the access control system is more extensive than simple MAC address-like sender-receiver pair of modems (for example, implementing full session authentication for KVM streams), the requirement is support of arbitrary authentication methods using a widely-supported "pluggable" authentication system like PAM. The intent is to allow sites to support their own krb5, dce, smartcard or other authentication systems.

In all cases, the configuration shall be scriptable via ASCII text interface or through some mechanism with a supported API for controlling clients. A web-style interface is not acceptable.

To support the case of a direct cable connection between sender and receiver, it shall be possible to disable this authentication process.

In order to facilitate the use of the same sender-receiver pairs in different security environments at different times, all non-volatile memory must be removable (so that the equipment configuration, if sensitive, can be swapped without requiring multiple sets of equipment).

2.12 Standardization

Minimal Requirements: The protocol used for the network delivery of analog and DVI signals over IP must be an open standard.

2.13 Usability

Minimal Requirements: Each sender and receiver shall be configurable by the user to set up a connection. Control capability shall meet authentication requirements above. A stand-alone configuration utility plus sample source code and API shall be provided.

Describe the configuration process, and each parameter needed to establish a successful connection.

Desired Capabilities: It may be useful to allow user access to internal low-level configuration parameters for adding special new functions.

2.14 Analog Video Response and Bandwidth

Minimal Requirements: Analog signal bandwidth for each color, through the modem pair shall be at least 250 MHz.

Desired Capabilities: Analog signal capabilities shall provide a response to a step input of ± 0.26 dB (97%) within 10 nsec, as well as conventional bandwidth of at least 300 MHz for each analog color signal.

3 Response Guidelines

If successful, this process may lead to one or more procurements for development in the areas chosen by the Tri-Laboratory community.

Your response should contain a high level of content describing specific areas of technological interest and capability that could be developed and commercialized. Your response should also discuss the following topics.

3.1 Current Status

What is the current status of the technology components you propose to develop or enhance? What is the current development path and schedule for the technology and what is the anticipated progress within the timeframe of the proposed work without additional ASCI project support and funding?

3.2 Collaboration

Provide a summary of any proposed collaboration and the background of the key technology providers/developers as it relates to the technology or technologies that form the basis of the project. Describe how the project will be managed and in particular how multiple organizations and/or independent contributors will be coordinated. Please explore Laboratory technology that could be licensable for this project.

3.3 Cost Sharing

We believe the technology and products developed by this project will be commercially viable. We believe that any company who develops these products should share or bear all costs of development. Please state how much of the costs your company is willing to bear.

3.4 Project Management

Describe the required budget, and timeframe for the project. Describe any access to Tri-Lab resources you may need. Discuss how the project would achieve a systematic acceleration in the indicated technology area over that described in the “current status” above. Indicate major milestones in the project during the proposed lifetime of the project. Propose several demonstrations of the product during its development phase.

3.5 Technology Productization Strategy

It is essential that responses not be framed as pure development efforts. Responses should have specific productization strategies to turn the technology into supported “high end” and “low end” application products by a specific vendor. Indicate how you will commit to commercialization of the developed technology. Indicate any barriers that to making such productization commitments in the future.

4 Contact List

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