Display Sharing:

An Alternative paradigm

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The current Johnson Space Center (JSC) Mission Control Center (MCC) Video Transport System (VTS) provides flight controllers and management the ability to meld raw video from various sources with telemetry to improve situational awareness. However, maintaining a separate infrastructure for video delivery and integration of video content with data adds significant complexity and cost to the system. When considering alternative architectures for a VTS, the current system's ability to share specific computer displays in their entirety to other locations, such as large projector systems, flight control rooms, and back supporting rooms throughout the facilities and centers must be incorporated into any new architecture.

Internet Protocol (IP)-based systems also support video delivery and integration. IP-based systems generally have an advantage in terms of cost and maintainability. Although IP-based systems are versatile, the task of sharing a computer display from one workstation to another can be time consuming for an end-user and inconvenient to administer at a system level.

The objective of this paper is to present a prototype display sharing enterprise solution. Display sharing is a system which delivers image sharing across the LAN while simultaneously managing bandwidth, supporting encryption, enabling recovery and resynchronization following a loss of signal, and, minimizing latency. Additional critical elements will include image scaling support, multi-sharing, ease of initial integration and configuration, integration with desktop window managers, collaboration tools, host and recipient controls.

This goal of this paper is to summarize the various elements of an IP-based display sharing system that can be used in today's control center environment.

I. Introduction

As the Mission Operations Directorate (MOD) looks for innovative ways to reduce the sustaining cost of its facilities, the MOD Operations Technology Facility (OTF) was requested to study the feasibility of alternative architectures for the video transport system (VTS). Most data seen by flight controllers consists of text and graphics. However, motion imagery is used as well and is delivered through the VTS. The current VTS is built of broadcast quality hardware and video cabling and requires specialized maintenance and support.

The current VTS satisfies the MOD requirement that a given computer display can be shared to other displays, such as the large projectors in the Flight Control Rooms (FCR), or a Picture-in-Picture window within any console position workstation. Any alternative architecture for the video system must at least satisfy this requirement.

A preliminary list of requirements for Display Sharing also includes
- The ability to share a screen or application in a one-to-one, one-to-many or many-to-many fashion
- The ability to scale the image based on the target's screen resolution and size
- The ability to easily configure and operate the display sharing system
- The ability to maintain a high level of performance and security

Display Sharing is not intended to be an alternative to straight IP video systems; Display Sharing delivers more than mere video. There are many ways to deliver imagery over IP. For example, the OTF uses commercially available third-party tools to share imagery through a remotely accessible session for X-Windows applications.

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This paper will review the existing MOD video infrastructure, the design approach that guided development of selection criteria, customers that have asked for specific requirements, the selection process which led to one product chosen to execute the Display Sharing prototype, a summary of this prototype process, and some final thoughts on the entire system.

II. Existing Video Infrastructure

Today's MOD video switching system includes analog and Serial Digital Interface (SDI) devices with BNC connectors and RF coaxial cabling and links a variety of sources ranging from standard def and high def cameras from ground systems or via space link. The video switching system can route multiple video inputs to a single recipient, or a single video input to multiple recipients. The video switcher is centrally located and all input sources and all recipients are connected to it. This system is illustrated in Fig. 1.

A switcher generally supports a single switchable format but may have the ability to convert multiple formats or multiple versions of a single format. Since there is likely to be different input formats and the recipients will generally require different types of output, external converters, video scalers, encoders

Figure 1. Video Switching

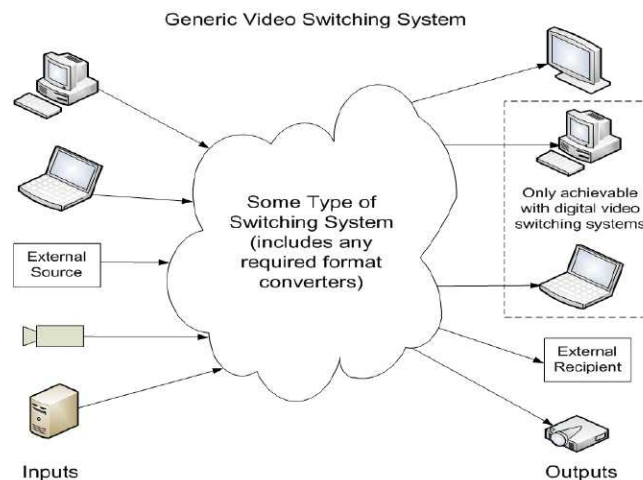and decoders may be required to match the inputs to the switchable format and to match the output to the recipients.

Fig. 2 provides an overview of the delivery of video to the control center or office environment via the existing IP infrastructure.
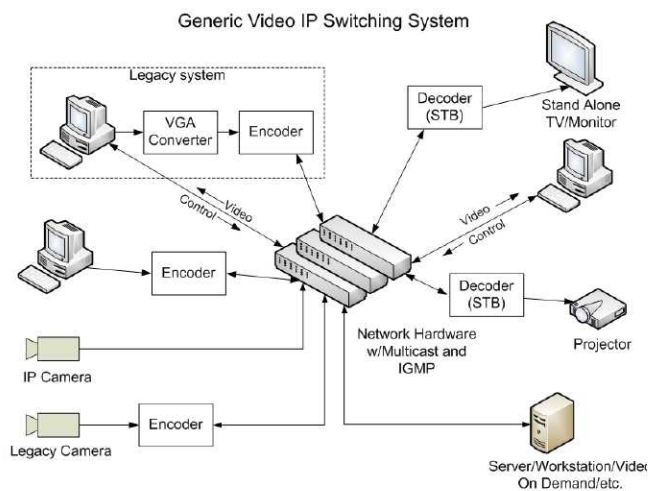

Figure 2. Typical IPTV

The basic capabilities of MOD's current analog/digital video system can be replicated with a well developed and secured IP video infrastructure. One major drawback of standard IPTV solutions is that they do not include the ability to share a given display directly to a specific target (the FCR projectors for example). This functionality must be added separately.

III. Design Approach

A prototype was developed to test and understand the possibilities and options available to share displays with other workstations. Prototyping is distinctive from a trade study. With a trade study specific requirements are defined, prioritized and weighted. A prototype on the other hand, uses a current commercial off the shelf (COTS) product to demonstrate the feasibility of using a specific product to meet requirements. As with most prototyping here in the OTF, a preliminary review of freely available tools and a comparison of vendor-provided data and analysis was made to select a specific product.

The objective was to prototype a method of sharing a display or specific application from one workstation to another within the MCC. The capabilities of the current VTS were surveyed to seed a list of requirements. The requirements were further refined to include security requirements necessary to ensure robustness and integrity.

Only pure software solutions were considered. Hardware-based solutions, such as video teleconferencing or IPTV, can offer viable alternatives to software-based display sharing. However, due to the hardware expense involved these options were excluded. A comparison of hardware vs. software solutions adds complexity and was beyond the scope of this effort.

3D rendering capability was beyond the scope of this prototype development due the additional cost of rendering tools as well as the limited time available to do development. However, this functionality is feasible for display sharing and an option for future enhancement.

Sharing information (whether a specific user application or an entire display) is often cumbersome to implement for both system designers and users, particularly where there is a requirement to share across operating system boundaries (Mac, Linux, Windows). This impacts display sharing application design. Attributes such as ease of operations, broadcast and multicast capability and, security are easily evaluated. Application performance can be difficult to measure, even with specific network bandwidth and local machine tools. The most difficult requirement to satisfy was the ability to share an application across different O/S platforms.

Ideas for requirements are often drawn from the features of a given vendor's product. However, requirements, when properly written, must be vendor-agnostic. The requirements for this prototype are grouped in the following areas.

A. Ease of operation to users
B. Configuration setup
C. Security
D. Group membership
E. Sharing displays with other operating systems
F. Manipulate the display
G. Communication protocol
H. Scalability from a host to a client
I. Recording and playback sessions
J. Application sharing versus desktop sharing
K. System administration functions
L. Performance
M. License and Cost
N. Handling Host Inactivity and Disconnections

A. Ease of operation to users

Users shall be able to easily share a display, whether within an O/S family or from a workstation running one O/S to a workstation running a different O/S without the aid of the administrator.

B. Configuration setup

The sharing application shall be configurable by an administrator. An administrator shall be able to manage user accounts and permissions as well as set up default configurations via a central management console across the LAN and WAN.

C. Security

The sharing shall support encryption for text and graphics. In addition sharing must adhere to all NASA security requirements governing firewall and network traversal among different O/S platforms. Use of a virtual private network (VPN) for sharing must not enable a user to circumvent NASA VPN security. Security measures applied at the application level shall apply to all child windows and dialogs.

D. Group membership

Authentication shall support Lightweight Directory Access Protocol (LDAP), or of Active Directory (AD) for single sign-on. Active Directory allows the implementation of Organization Units (OU) to define groups of users. Export control review may be necessary to verify that groups do not contain ineligible individuals.

A user shall have the capability to share applications to such groups. A user shall also have the ability to broadcast or multicast, through a secure port, without any group membership required of the recipients (although the content may be subject to export control). There shall be no theoretical limit to the maximum number of individuals or groups of individuals that can share applications or displays, although there may be a practical limit due to local machine resources and network bandwidth. An administrator shall have the ability to add or change group member's settings for managing the process. An administrator shall also have the ability to grant access to any individual within the already developed shared group.

E. Sharing displays with other operating systems

As sharing may be required between various O/S platforms including Microsoft Windows (32- or 64-bit), Linux (32- or 64-bit) and MAC, security vulnerabilities that may exist when crossing platforms must be addressed.

F. Manipulate the display

The host (sharing) user shall be able to control whether a shared display or application is read-only or read/write for the recipients. The area shared is also known as the "active real estate". For collaboration support, the system shall provide the ability for a client user to mark up the shared application.

1. Viewing shared applications

When sharing an application, the system shall automatically share that application's child windows and dialogs.

2. Editing shared applications

A host shall be able to share an application for read/write state and any child windows and dialogs of that application are also shared in the same state.

3. Marking up a shared application

The user shall be able to mark up the shared application and any child windows and dialogs. Mark up is defined as using any basic drawing or collaboration functionality to enhance the communication effort required by the client back to the host or vice-a-versa.

G. Communication protocol

File sharing, Internet message chatting, white board products and File Transfer Protocols (FTP) that manipulate and move data shall not be shared due to heavy security risks.

Broadcast and or Multicast functionality shall use standard industry protocols. The publication/subscription method can be used to implement one-to-many interactive or non-interactive sharing. Broadcast is analogous to a radio transmitting a signal to unknown number of receiving sets or to a closed circuit TV broadcast, where any TV on the circuit can receive the broadcast. Multicast is analogous to publishing a magazine to a specific list of subscribers, which means a specific list of IP/ports addresses.

Broadcast display sharing is always read-only to the client and the client or clients are anonymous; the sender does not know what clients are receiving the transmission. Therefore content security can be difficult if not impossible to enforce. Specifically, as the viewing community is anonymous, broadcast cannot easily facilitate export control.

Multicast is likewise always read-only to the client, is delivered only to a specified list of clients, and availability may be restricted to levels of access (which could, for example, be defined by the firewall boundaries which limit

the range of a multicast). Elements of multicast which must be considered include PIM-DM[2] / PIM-SM[3] multicast protocols, varying ranges of low bandwidth consumption, ranges of acceptable latency, acceptable packet loss and artifact deduction ranges, and the establishment of user groups to facilitate export control by enabling a user to multicast to a specified group of users who have been cleared for export (though it must be understood that multicast functionality cannot enforce export control restrictions on any content).

H. Scalability from a host to a client

Scalability means the ability to resize a shared application's screen "footprint" on the client machine. The system shall be able to automate the resolution factor from one machine display to another (without any user knowledge of the two machines' display resolutions). Display size on the client shall also be controllable by the client based on a resolution factor or by allowing the host or even another client to resize the shared window.

I. Recording and playback sessions

The system shall include built-in recording capability, which will record in industry standard formats such as MPEG4/H.264 for playback by widely available players.

J. Application sharing versus desktop sharing

"Application" sharing is distinct from "Desktop" sharing. Application sharing shares a single application (including any child windows and dialogs) displayed on a user's workstation, whereas desktop sharing shares some or all of a user's screen real estate. Most products default to desktop sharing of the host's entire primary monitor, however, the system administrator shall be able to configure which is the default.

When sharing the desktop of a multiple monitor host, the system shall allow the user to select which monitors' real estate is shared.

Both broadcast/multicast sharing and sharing direct to a specific individual or group shall be supported for both application and for desktop sharing.

Some products allow the host to select the application from a list of running applications, but this can be cumbersome if the number of open applications is high. The system shall allow the user to select directly from among the active windows.

K. System administration functions

The administrator shall be able to monitor the sharing system for performance. The system shall prepare reports, message logs and statistics to troubleshoot performance and to resolve issues.

The system administrator shall have root access as needed on the host O/S in order to resolve technical issues for any of the components of the sharing process. This may include access to the application server or host, the client machine(s), and any other component needed to setup or configure the sharing process.

The "Statistics" function shall be gathered on:

- Host / client latency
- Upload speed
- Connection, user and client counts

A "Message Logs" function shall provide real-time data and shall include:

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[2] http://www.networkdictionary.com/protocols/pimdm.php
[3] http://www.networkdictionary.com/protocols/pimsm.php

- Start / Stop timestamps of sharing activities between a host and client or set of users.
- Logs of application crashes which capture as much corrupt data as possible for analysis.
- Version number

An "Operator / Name Directory Interface" function shall include such features as adding and removing members through the LDAP service (or equivalent), editing groups for user flexibility and password re-activation for locked accounts. Although not required, it is recommended that user registration be automated. Data that shall be recorded includes:

- Name / User ID (recommend LDAP registration, but not required)
- Group (This will help specific groups of individuals to communicate easier)
- Initial timestamp for first time users
- Last recorded logout timestamp

L. Performance

Although performance can be difficult to evaluate and manage, the system shall be able to address issues of:

- Latency. Ideally there shall be no more than 1 second of latency between host and client.
- Network bandwidth consumption.
- Burden on local CPU and memory usage.
- Frame rate. Text data shall update at a minimum frame rate of 1 Hz. Prerecorded animations and modeled simulations shall update at a minimum frame rate of 10 Hz.

M. Licensing and Cost

Cost is a factor in determining the whether to use a particular sharing application. Not all products require a license. Some provide a free download. Some products require a license for each separate server and each client. Some products are licensed on a monthly basis and some require an annual subscription. When it comes to tech support, as with many other products, the more you spend, the more you get. The ideal product can be downloaded free and implemented with minimal tech support.

N. Handling Host Inactivity and Disconnections

The display sharing system must be able to handle unexpected behavior to ensure a smooth user experience.

1. Inactive Host Sharing

Most operating systems have lock out / screen saver / black out features which activate after a period of inactivity. However, the Display Sharing application shall continually push imagery out even when the host's display mode is inactive and until the host deactivates the sharing.

If a portion of the shared application's real estate on the host is obscured by another host application's window, the shared application shall still be shared completely, including the covered-over portion. If, however, there is no means to continue sharing a hidden application (be it screen-locked or having additional applications over it), then the sharing host must show what is currently active and what is not (what is updating to the client and what is "frozen").

2. Resynchronization

As networks can go down, a host sharing application must be able to resynchronize with its clients. When communication is reestablished the current shared display on the client shall pick up from the host's current feed.

IV. Different Customers

In compiling the proposed requirements for this document certain customer groups at JSC were polled for input. Although there will be other interested customers, customer use of display sharing generally brakes down into four areas of interest: Flight Control Rooms, Application Broadcasting, Conference Room Collaboration, and Training and Simulation.

A. Flight Control Rooms

Flight Control Room (FCR) users require the ability to share any flight control discipline application (applications run on 2D X11-based Linux O/S) to a variety of clients, including each other's workstations, the large projected screen, and, via secure remote access, to both the office environment and remote users.

The sharing application shall support cross-platform sharing of X11-based displays to Windows. When a host shares out to the passive unmanned control center projector client, the host user must be able to remotely control the projector client in order for the client to interact with the shared display. For workstations with extended desktops (workstations with multiple monitors) all monitors and monitors' real estate must be sharable.

B. Application Broadcasting

Application Broadcasting is the ability to publish, as read-only, any VTS application (including graphics and data) to the local MOD operations (OPS) intranet so that a large number of clients may subscribe to it (a one-to-many process) and view the data in a quick, secure and convenient way over the LAN. Any subscription process must work cohesively with existing certified applications and the operating system of the unmanned PC workstation that is currently publishing the graphics and data through the VTS. It is recommended that the "One-to-Many" technique utilize multicast protocols to ensure that network traffic can be managed for hundreds of viewers. A proposed test to demonstrate this is described in Fig. 4.
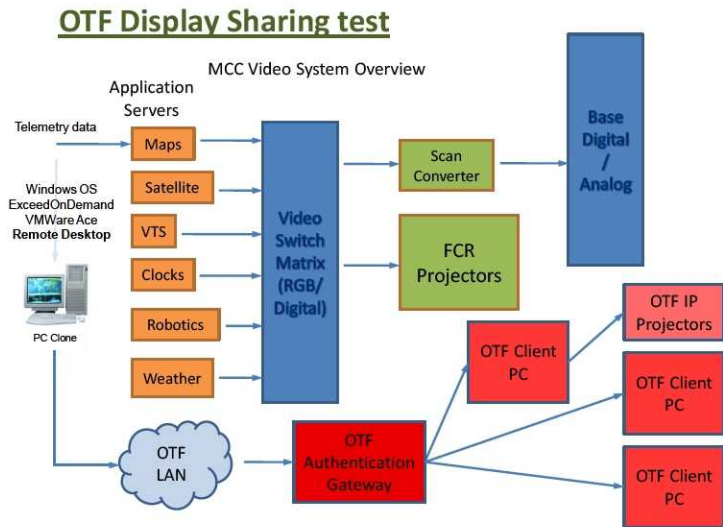

Figure 4. Application Broadcasting

In this example MCC telemetry is fed into a variety of application servers, which feed into the MCC VSM. The VSM then converts that data for output to multiple clients, including the Scan converter and the FCR projectors. The Scan converter receives the output of the VSM and converts it to base digital / analog for further distribution. Telemetry is also fed into a virtualized PC and from there is output to the OTF LAN. OTF client PCs and IP projectors authenticate to the OTF LAN to receive this feed.

C. Conference room collaboration

Conference room collaboration users require the ability to share any applications (most commonly the entire desktop) by pairing both subscription models ("push / share" and "pull / broadcast") in a quick, secure and convenient way to share the data over an existing network. This is shown in Fig. 5.

D. Training and Simulation

Training and simulation users require an ability to share any flight controller's application in an instructor to student led training exercise over the network. Training and simulation use encompasses all Flight Control Rooms sharing

Conference Room Collaboration

Figure 5. Conference room collaboration

requirements with the addition of training-specific tasks. The instructor must be able to control imagery shared from their student's entire desktop without the student being aware of the instructor's actions. The instructor must be able to select particular monitors from the student's workstation in order to manage the training. Instructors may also require the use of recording and playback features in order to run simulations.

V. Selection Process

Different methods for moving imagery across the web are available. Web conferencing, video conferencing, desktop / application sharing, remote access transport protocols, collaborative sharing, and even IPTV can execute elements of Display Sharing.

A display sharing architecture could be any of the following types: client / server, multipoint control unit (MCU), peer-to-peer, and multicast. These methods must work on many existing operating systems, virtualization access schemes, and across network firewalls and the Internet and support sharing among small or large client populations.

Comparison chart

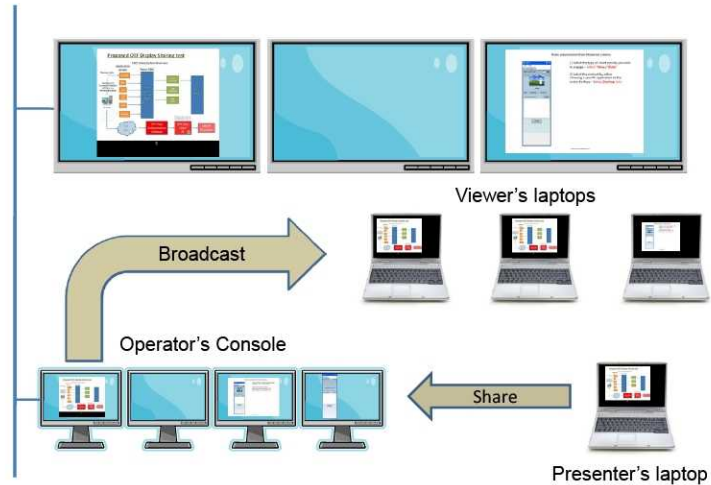| Software	Protocol	License	Client/server	Built-in encryption	File transfer	Audio support	Multiple sessions	Seamless window
AnywhereTS	RDP, ICA	Proprietary	Client Only	SSL, TLS	✓	✓	✓	X
Apple Remote Desktop	RFB(VNC)	Proprietary	Client & Server	AES-128	✓	X	✓	X
Apple Screen Sharing (iChat)	Proprietary, RFB(VNC)	Proprietary	Client & Server	AES-256	X	X	✓	X
Bomgar	Proprietary, X11	Proprietary	Client & Server	SSL, AES-256	✓	X	✓	✓
Cendio ThinLinc	RFB(VNC)	Proprietary	Client & Server	SSH	✓	✓	✓	✓
Chicken of the VNC	RFB(VNC)	GPL	Client Only	X	X	X	X	X
Citrix XenApp	RDP, ICA	Proprietary	Client & Server	SSL, TLS	✓	✓	✓	✓
Crossloop	RFB(VNC)	Proprietary	Client & Server	✓	✓	X	X	X
DameWare Mini Remote Control	RDP, Proprietary	Proprietary	Client & Server	SSL, AES-256	✓	✓	✓	X
EchoVNC	RFB(VNC)	GPL	Client & Server	✓	✓	X	✓	X
Ericom PowerTerm WebConnect	RDP, RFB(VNC)	Proprietary	Client & Server	✓	✓	✓	✓	✓
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TeamViewer	Proprietary	Proprietary	Client & Server	AES-256	✓	X	✓	X
TightVNC	RFB(VNC)	GPL	Client & Server	X	✓	X	✓	X
Timbuktu	Proprietary	Proprietary	Client & Server	✓	✓	X	✓	X
UltraVNC	RFB(VNC)	GPL	Client & Server	With plugin	✓	X	✓	Partial[18]
Webex	Proprietary	Proprietary	Client & Server	✓	✓	✓	✓	X

Figure 6. List of Remote Desktop Software

An enterprise solution can be difficult to describe. Vendors' solutions were often rigid and inflexible. A vendor willing to adapt their product for prototyping was typically favored. To speed vendor selection it was determined that quick comparison charts provided by industry-driven services could suffice to compare the options available from vendors. Fig. 6 is a screen shot of a comparison of remote desktop software in Wikipedia[4].

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[4] http://en.wikipedia.org/wiki/Comparison_of_remote_desktop_software#cite_ref-2

Fig. 7 is a screen shot of a Web Conference applications[5] comparison, also in Wikipedia.

Display Sharing can be considered a subset of real-time collaboration solutions, making it difficult to clarify the definition of Display Sharing. For comparison the reader may consider a Wikipedia-compiled lists of collaborative software packages[6] and of video conference applications[7].

These charts are by no means comprehensive and absolutely authoritative.

Program	License	Capacity	Linux	Mac OS X	Microsoft Windows	Audio Support	Video Support	Chat Support	Desktop Sharing Support
Adobe Acrobat Connect	Proprietary	80,000[1]	✓	✓	✓	✓ with two-way teleconference integration	✓	✓	✓
Cisco Unified Meeting Place	Proprietary	7,500	✓	✓	✓	✓	✓	✓	✓
Citrix GotoMeeting	Proprietary	15	X	✓	✓	✓	✓	✓	✓
Citrix GotoWebinar	Proprietary	1000	X	✓	✓	✓	✓	✓	✓
Dimdim	GPL + Proprietary	20 - 1,000	✓	✓	✓	✓	✓	✓	✓ only as viewer in Linux
Genesys Meeting Center	Proprietary	??	X	X	✓	✓	X	X	X
Glance	Proprietary	100	✓	✓	✓	X	X	X	✓
IBM Lotus Sametime	Proprietary	Unlimited	✓	✓	✓	✓	✓	✓	✓
IBM Lotus Sametime Unyte	Proprietary	999	✓	✓	✓	✓	✓	✓	✓
Microsoft Live Meeting	Proprietary	20,000	✓	✓	✓	✓	✓	✓	✓
Netviewer	Proprietary	100	X	X	✓	✓	✓	✓	✓
omNovia Web Conference	Proprietary	5,000	✓	✓	✓	✓	✓	✓	✓

Figure 7. Web Conference Products

Rather the charts provided a starting point for vendor comparison. Licensing and cost concerns are summarized in section III, part M.

A set of rules was developed to speed the prototyping process and explore the fundamentals of the Display Sharing experience. Here are some activities carried out prior to testing:

- Surveyed top-tiered vendors for product and support data.
- Vendors requiring monthly subscriptions and fees were eliminated in favor of those offering free trials.
- Other vendors supplied demo versions of latest products with adjustments to accommodate our needs.
- Excluded any audio and video functionality from testing.
- Two (2) Windows and two (2) Linux machines were prepared for testing.
- Did not pursue any testing of platforms other than Windows and Linux.
- After installing, each was tested for ease of operation.
- Used basic network analysis tools to help understand network and machine performance.

After selecting a few products to work with, user requirements and preferences were prioritized. Table 1 shows these basic requirements across the top with some vendors representing different methodologies listed in the left column. These products were evaluated with the simple results as shown in Table 1.

Table 1.	Display Linux Apps	Latest Encryption	App. Sharing	App. Children Shared	Display[8] Window Applications	Easy Actions[9]	Performance		
							Latency	Resolution	Network Bandwidth
Remote Access[10]	Y	Y	Y[11]	Y	N	N	< 1 sec	Nominal	Nominal
Remote Access[12]	N	Y	N	N	Y	N	< 1 sec	Nominal	Nominal
Video Conference	N	Y	Y	N	Y	Y	< 1 sec	Better	Better
Remote Access	Y	Y	N	N	Y	N	< 1.5 sec	Below	Nominal
Web Conference	N	Y	N	N	Y	Y	< 1.8 sec	Well Below	Nominal

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[5] http://en.wikipedia.org/wiki/Comparison_of_web_conferencing_software
[6] http://en.wikipedia.org/wiki/List_of_collaborative_software
[7] http://en.wikipedia.org/wiki/List_of_video_telecommunication_services_and_product_brands
[8] All products are capable working on a Microsoft Windows environment.
[9] Products requiring no admin support in order to install were regarded as easy to operate.
[10] Linux or UNIX-based (Linux / UNIX server to Linux or Windows clients)
[11] Requires user to participate in a single window mode.
[12] Windows-based only (Windows Server to Windows clients only)

While it would be best to evaluate all aspects of display sharing using commonly accepted trade study practices (i.e., build criteria and weigh the priorities, with complete freedom of product and feature selection), not all decisions were under the control of this study. The study was constrained where Linux-to-Linux and Linux-to-Windows transport was concerned as the OTF had selected remote access as its transport process. (This can remotely deliver 2D X-11 Linux applications to the Microsoft Windows environment.)

Others were chosen to help develop a prototype for Windows-to-Windows sharing that could support all of the possible requirements of the MOD customers. This prototype had to satisfy the requirements of various customers as reviewed in "Differing Customers" previously. A video conference company focusing on a high end user experience through the Internet using a highly secure encryption process, along with very low usage of network bandwidth and minimal workstation CPU resources was selected for further investigation. Their Display Sharing architecture is based on this same video conference method utilizing a system administered gateway that includes a name authentication server as a means to collect and preserve members' authorization data and a relay server for firewall traversal. An example of a display sharing enterprise architecture is shown in Fig. 8.

The ability to deliver real-time adjusted pixel-to-pixel movement or pixel interpretation through a peer-to-peer client application allows the different JSC MOD customers to test their specific requirements.

Video Conference products can couple their developed display sharing activities using the same gateway infrastructure (Fig. 8), as a list of security and maintenance benefits to collaboration efforts. This list may include:

Figure 8. Display Sharing Architecture

- Owning the sharing process, rather than rent it. (No Web-subscribed products, no monthly fees, etc.)
- Capable of working with common "Name Authentication" Server via LDAP / Active Directory, which can be UDP or TCP port configurable
- Capable of working with common "Relay Server" to help traverse through existing firewalls, which can be UDP or TCP port configurable
- These systems supports single sign-on authentication to minimize group permission issues
- These systems use an encrypted solution
- If peer-to-peer access fails, then a UDP-to-Relay server process, followed by a   TCP-to-Relay   server process can sustain the connection.
- File sharing / file transfer mechanism is not enabled
- Video IP packets are not sent
- Audio IP packets are not sent
- Chat interactivity (including IRC) is not enabled
- Interactive broadcasts can be password enabled for a dozen viewers (peer-to-peer only, not true multicast)
- Collaboration annotation (mark up and review tools) is sent pixel-by-pixel (only changed pixels are sent)
- Remote control of a client is available (requires some administrative configuration).
- Host must be actively participating in a sharing session. Sharing is suspended if the host's Windows workstation is locked or the screensaver is active.
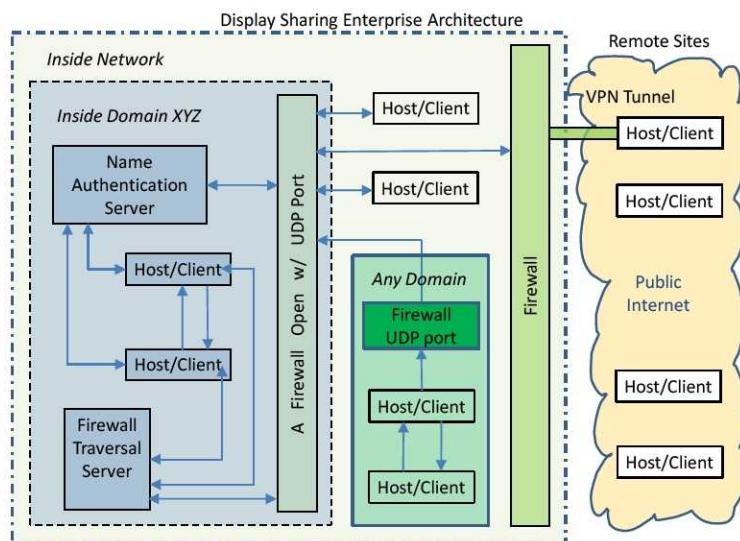
VI. Summary

During the Display Sharing prototype development process most well-featured products could not fulfill all requirements. However, there were many advantages to pixel interpretation for this early prototype. Table 2 provides a quick summation of those pros and cons of these capabilities as they applied to the prototype.

Table 2. Development Insights

	Favorable actions	Unfavorable concerns
Ease of Operation to users	A separate GUI can been designed to help share imagery by selecting the appropriate push / pull model, that displays a quick thumbnail of the suggested shared space, confidently depicts active members that could participate in the sharing process, displays the recipient's real estate for size and placement, and logs the actions to a message screen. The pull process displays Broadcasts that are currently viewable by permission status. Messages can be logged to a status area for reference.	Currently no user feedback mechanism to help support this feature exists. Members shall have the capability to denote issues or concerns with specific features to a designated process.
Configuration setup	Users may simply download the application from a local NASA repository; authentication automatically performs with local JSC credentials, ready for sharing.	Some products require that the users must have root access to download, otherwise permission is denied. This can be cumbersome to administer.
Security	Some products use an encryption process over a Peer-to-Peer assigned UDP port, however if this fails, it automatically uses UDP Relay Server and if this fails, it can use the TCP Relay through port 80 or 443 (unsecured and secured public Internet)	Offsite communication tactics may require VPN traversal (if no Firewall traversal solution exists) that may indeed demonstrate slower performance characteristics.
Group membership	Some products display both active and non-active participants in designated groups allowing the user to understand whose on or not. Some have the ability to configure and manage personal groups as well.	Some do not currently use all authentication features that would help dictate permission concerns with specific groups. Automatically embedding active directory features would help.
Sharing displays to different O/S	Some are designed for all of the latest Microsoft Windows environments: 2000, XP, 2003, Vista, and Windows 7.	Some Windows applications do not support Linux/UNIX and Apple MAC O/S. Web Browser plug-ins may be a way to incorporate temporary resolutions, but will need to include cross-platform solutions.
Manipulate the existing display	Annotation features allow the host and recipient to communicate with chosen colored scribble pen and text features on the designated shared real estate. The ability to quickly erase the annotation resets the communication for more whiteboard like updates.	Action Buttons can appear within the controlled shared real estate at times, thus disallowing the user to interact under those features. Color and text palettes are usually pretty weak with no control. Some erase features usually erase all annotations, not separately. Most do not capture annotations for storage and playback.
Communication protocol	Some Broadcast features are controlled by a password for a dozen or so interactive clients to participate with.	Most do not support a true multicast for one-to-many subscribed viewers. Request is generally stated for more than a few hundred specific viewers. Security does not have the ability to disable any broadcast.
Scalability from client to client	A few products feature a host to remotely change the size and placement on the client of the prepared shared real estate by previewing the layout for each selected client. Once shared a client can then move or resize the shared image to suit.	When receiving a multiple-monitor broadcast clients should select a specific set of monitor(s) from among the monitor images shared from the host and exclude others, but some products only dictate the primary desktop as the only source of the monitor images shared.
Recording / Playback	Some products have the ability to record / playback.	Most products do not support this feature.
Application vs. Desktop sharing	Applications can be selected based on a list of existing applications currently located on the viewable desktop or simply by selecting the appropriate window to be shared. Some desktop features can be stretched to accommodate many monitors or a region of real estate.	Most products dictate the desktop sharing function by presenting the primary monitor as a source of shared real estate. Some products do allow the controllable area to be stretched, however this process does not maximize the viewing portion for the recipient to choose which monitor or set of monitors that exist from the host broadcasting its desktop.

	Favorable actions	Unfavorable concerns
System Administration functions	Some demonstrates network statistics, shared connection statistics, logged messages, and a means to adjust specific permissions to group members.	Most do not provide a significant factor to group specific individuals of an Active Directory listing. Some products allow members to see all active memberships within designated groups, thus providing confidential detail.
Performance	A few can support many Flash animated playbacks that could result in performance of over 20 Hz (frames / second), thus allowing latency to be minimal. Application or Desktop sharing bandwidth consumption is minimal due to pixel adjustments only, thus capable of less than 100 kb / sec bandwidth. Some can have a low CPU consumption as well.	As more recipients view a particular host's shared imagery, most products lacks assistance with CPU performance. Certainly not recommended for raw or true video sharing, although this can be coupled with a third party performance accelerator to enhance performance, but they tend to cause more harm than good.
License & Cost	A yearly maintenance fee allows up to hundreds of members to communicate through a repository for permissions and activation was best suited.	There will be a specific dollar amount per year for maintenance costs on any of the supporting servers.
Inactive Host Sharing	Ability to shut down the sharing process when the host screen itself appears to be blacked out through locked screens or power savings.	The user community would like the sharing process to continue without hesitation from the host.

The OTF continually investigates this prototype process by enhancing and upgrading the process based on our experience and feedback in order to continually improve the prototype. Development of the prototype has proceeded with the awareness of some limitations.

- As of this writing, many products support Microsoft Windows based sharing only. There are web plug-ins in development to help support other operating systems. The Mac operating system can be integrated with Windows emulators like Fusion and Boot Camp. There are no current Linux or UNIX available.

- Some products application broadcast feature only allows about a dozen viewers and uses a peer-to-peer connection process. This may be described better as a publication of only a dozen books and only a dozen subscribers can view the publication. This is not a true Multicast, which acts like the radio transmissions that are picked up by any amount of receivers. Some products broadcasts could be allowed to accept a password controlled view for the client, although the host may need to turn the client's interactivity mechanism off. It may be necessary to include additional broadcast features for the one client.

- Be aware that specific Windows application functions can tend to bleed into the Host controlled real estate. Windows can be configured to turn off specific effects like; the Shadow under menus, the Window contents while dragging feature and the Fade (transparent) effect on transitioning effects for menus and tooltips – to help minimize the undesired sharing artifacts. Using a pixel interpretation process can help distinguish between a live update and no change, thus providing a benefit of low packet traffic on an IP system. However, if any of the active shared real estate is obstructed by other windows or effects, then the shared imagery may be interrupted. Although this is not optimal, some products can clue the client / user by conveniently shading the desired viewing area where any updates are not coming through, so that the client user may ask the host to move the obstructing window.

- Although a third party "Performance Accelerator" can improve performance, it can also impede video setting configurations for other visual / imagery products such as; Ultramon[13], VLC[14], any VNC[15] product or window management tool[16]. It is recommended that any window manager products present be tested for possible conflicts or interference.

- Collaborative "Actions Buttons", which can control and annotate the shared region, can be a nuisance by obstructing valuable real estate that may require interaction. The testers prefer that any Action buttons be hidden and instead behave like the Microsoft Windows Remote Desktop mechanism that appears and disappears depending on mouse rollover.

- Most products do not support a mechanism for "Export Control" compliance (US government secured content) other than perhaps utilizing the Organizational Units (OU) of the Active Directory, where the OU helps describe permission levels for a particular group of users.

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[13] Ultramon, from Realtimesoft, a desktop monitor management tool, http://www.realtimesoft.com/ultramon/

[14] VLC, from VideoLAN, a media player for network streaming protocols, http://www.videolan.org/

[15] VNC, http://en.wikipedia.org/wiki/Virtual_Network_Computing

[16] http://en.wikipedia.org/wiki/Window_manager

VII. Conclusion

While there are many products that can provide solutions which possess some attributes / features of Display Sharing, there may be few products that can satisfy all requirements. Desired attributes and features must be prioritized in order to determine which products can best meet known requirements. A prototype was developed to provide Display Sharing strengths and weaknesses. Proving the concepts of Display Sharing and demonstrating possible tools to the MOD community has allowed us to uncover invaluable information to help MOD users perform their tasks quickly, efficiently and with better cost effectiveness.

With the advent of Digital Video techniques, IPTV and many network streaming protocols within the JSC network infrastructure, Display Sharing can be overlooked and regarded merely as a minor tool to visualize ideas. While the ability to share screen information through many types of IP session based screen sharing tools provides you duplicated data and graphical updates, clients do not receive a pure pixel interpretation from the host to a client or to set of clients. Pixel interpretation allows the client to not be reliant upon the specific application that delivers the graphical update. However, a Linux-to-Windows graphic transport (a remote accessible session) coupled with a Windows-to-Windows display sharing product, an alternative method was introduced to the JSC community offering significant and thought-provoking options for successful collaboration via shared displays and applications across the network.

Display Sharing:
An Alternative Paradigm

Mike Brown
MOD / JSC

Introduction

- MOD looks for innovative ways to reduce costs
- Study alternative architectures for the current Video Transport system (VTS)
- Current VTS satisfies MOD requirements to share display imagery in Flight Control Rooms (FCR)
  - Sharing to Large Projector Screens
  - Picture-in-Picture Windows
  - Other back area control rooms
- Preliminary additional requirements
  - Ability to share a screen or application to one or many
  - Ability to scale imagery to target's screen resolution & size
  - Ability to easily configure and operate
  - Ability to maintain high level of performance & security
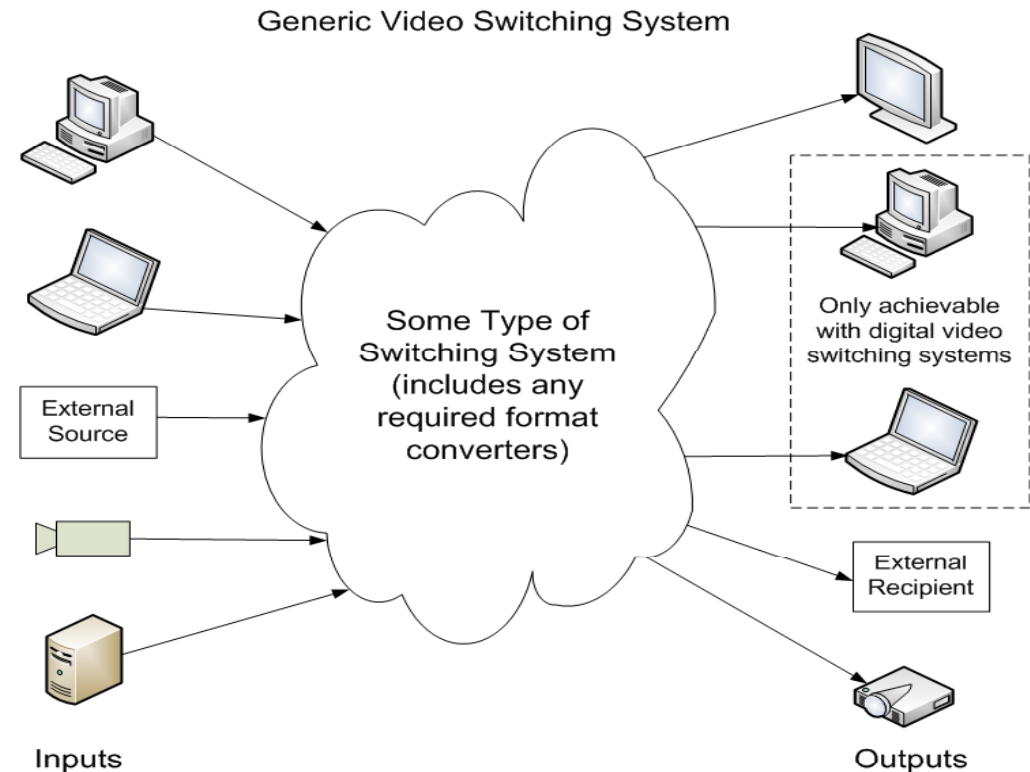
Introduction

- ## What is Display Sharing?

  - Not intended to be an alternative to IP video systems

  - Delivers more than just video

  - Need to understand the existing video infrastructure

  - Look for a Design Approach

  - Customer driven requirements

  - The Selection Process

  - Collection Summary

Video Infrastructure

Using a variety of sources ranging from standard & high def cameras from either the ground or in space and differing computer displays, a video switch system can route imagery to multiple types of recipients using the existing RF cabling and BNC connector VTS that has been developed for many years.

Generic Video Switching System

Some Type of Switching System (includes any required format converters)

Only achievable with digital video switching systems

External Source
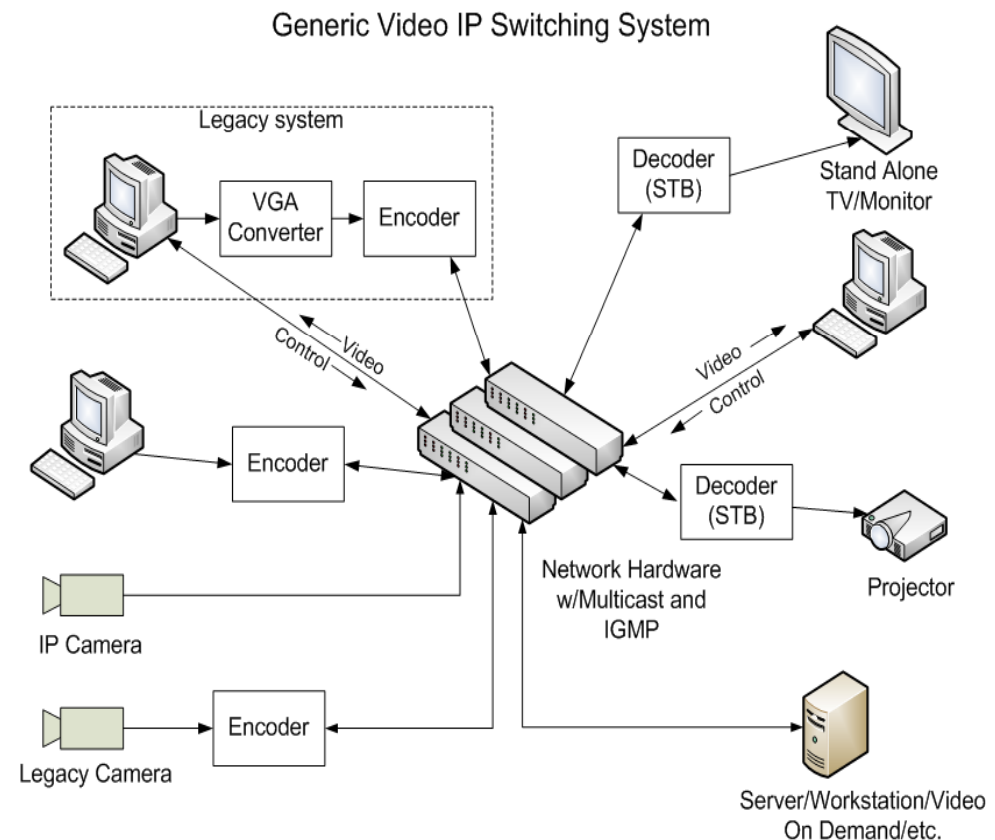
External Recipient

Inputs

Outputs

Video Infrastructure

A well proven IP Video system has the ability to duplicate many of the current requirements of the VTS and could be more cost effective.

However specific image sharing would require additional configuration and maintenance that can be cumbersome, slow and inconvenient.

Generic Video IP Switching System

Design Approach

- Develop a prototype using commercial off-the-shelf (COTS) products to demonstrate its feasibility
- Use freely available tools and comparison charts
- Share a display or specific application from one workstation to another within Mission Control Center (MCC)
- Use existing VTS to help seed a list of requirements
- Include security IP requirements
- Only software solutions were considered – no access to hardware costs
- No 3D rendering was considered due to costs although sharing 3D graphics would impact results

Design Approach

- ## A list of requirements based on initial testing
  - Ease of operation to users
  - Configuration setup
  - Security
  - Group membership
  - Sharing displays with other operating systems
  - Manipulate the display
  - Communication protocol
  - Scalability from a host to a client
  - Recording and playback sessions
  - Application sharing versus desktop sharing
  - System administration functions
  - Performance
  - License and Cost
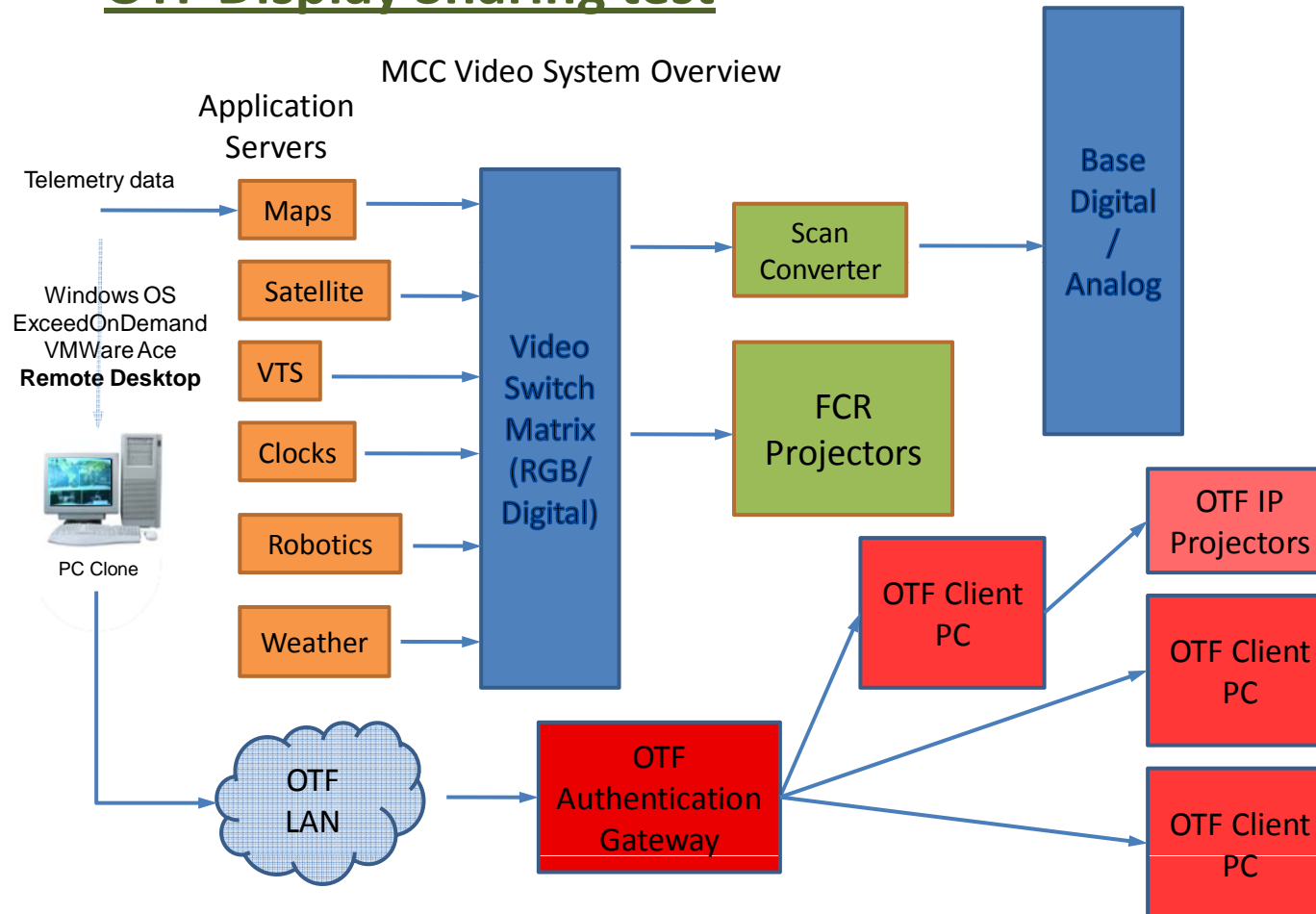 - Handling Host Inactivity and Disconnections

Different Customers

- Flight Control Rooms
- Application Broadcasting
- Conference Room Collaboration
- Training & Simulation
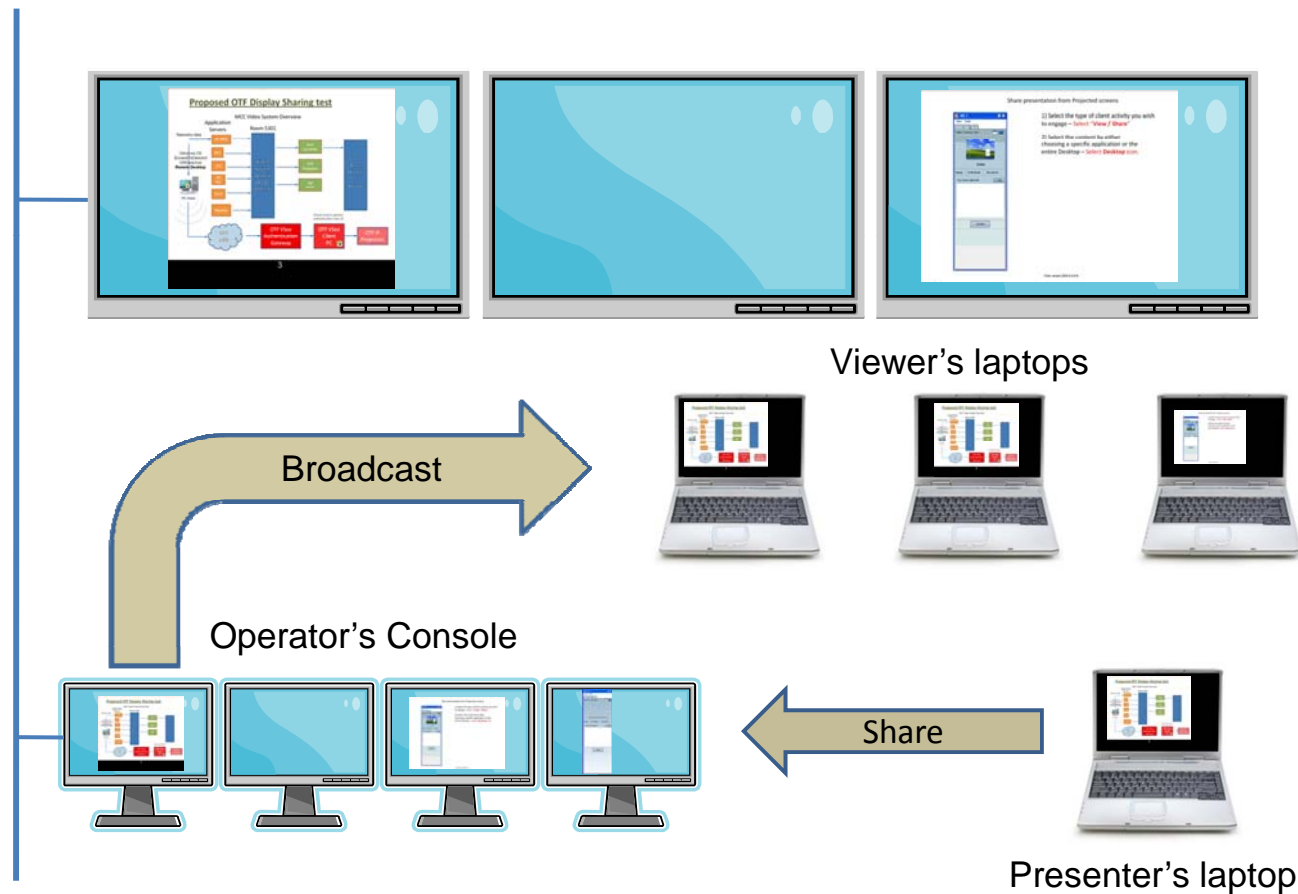
Application Broadcast

OTF Display Sharing test

MCC Video System Overview

Conference Rooms

Conference Room Collaboration

Viewer's laptops

Broadcast

Operator's Console

Share

Presenter's laptop

Selection Process

- ## Different methods to move imagery across a secured IP network include:
  - Web Conferencing
  - Video Conferencing
  - Desktop or Application Sharing
  - Remote Access Transport protocols (session-based)
  - Collaborative Sharing
  - IPTV
- ## Display Sharing Architectures could be created as:
  - Client / Server
  - Peer-to-Peer
  - Multicast

Selection Process

- Any of these methods must work on:
  - Existing Operating Systems
  - Virtualization access schemes
  - Across Network Firewalls and the Internet
  - Support up to large client populations

- An Enterprise Solution can be difficult

- Vendors' solutions were often rigid and inflexible

- Used various comparison charts to quickly determine suggested products

Selection Process

- Although Wikipedia is not considered factual information, it can be a fairly quick source of analysis.

- Several Wikipedia charts exist today comparing several products including:
  - Remote Desktop (http://en.wikipedia.org/wiki/Comparison_of_remote_desktop_software#cite_ref-2)
  - Web Conference (http://en.wikipedia.org/wiki/Comparison_of_web_conferencing_software)
  - Collaborative products (http://en.wikipedia.org/wiki/List_of_collaborative_software)
  - Video Conference (http://en.wikipedia.org/wiki/List_of_video_telecommunication_services_and_product_brands)

Selection Process

- Set of rules was developed to speed the prototyping process and explore the fundamentals of the Display Sharing Experience.
  - Surveyed top-tiered vendors for product and support data.
  - Vendors requiring monthly subscriptions and fees were eliminated in favor of those offering free trials.
  - Other vendors supplied demo versions of latest products with adjustments to accommodate our needs.
  - Excluded any audio and video functionality from testing.
  - Two (2) Windows and two (2) Linux machines were prepared for testing.
  - Did not pursue any testing of platforms other than Windows and Linux.
  - After installing, each was tested for ease of operation.
  - Used basic network analysis tools to help understand network and machine performance.

Selection Process

	Display Linux Apps	Latest Encryption	App. Sharing	App. Children Shared	Display[1] Window Applications	Easy Actions[2]	Latency	**Performance** Resolution	Network Bandwidth
Remote[3] **Access**	Y	Y	Y[4]	Y	N	N	< 1 sec	Nominal	Nominal
Remote[5] **Access**	N	Y	N	N	Y	N	< 1 sec	Nominal	Nominal
Video Conference	N	Y	Y	N	Y	Y	< 1 sec	Better	Better
Remote Access	Y	Y	N	N	Y	N	< 1.5 sec	Below	Nominal
Web Conference	N	Y	N	N	Y	Y	< 1.8 sec	Well Below	Nominal

[1] All products are capable working on a Microsoft Windows environment.
[2] Products requiring no admin support in order to install were regarded as easy to operate.
[3] Linux or UNIX-based (Linux / UNIX server to Linux or Windows clients)
[4] Requires user to participate in a single window mode.
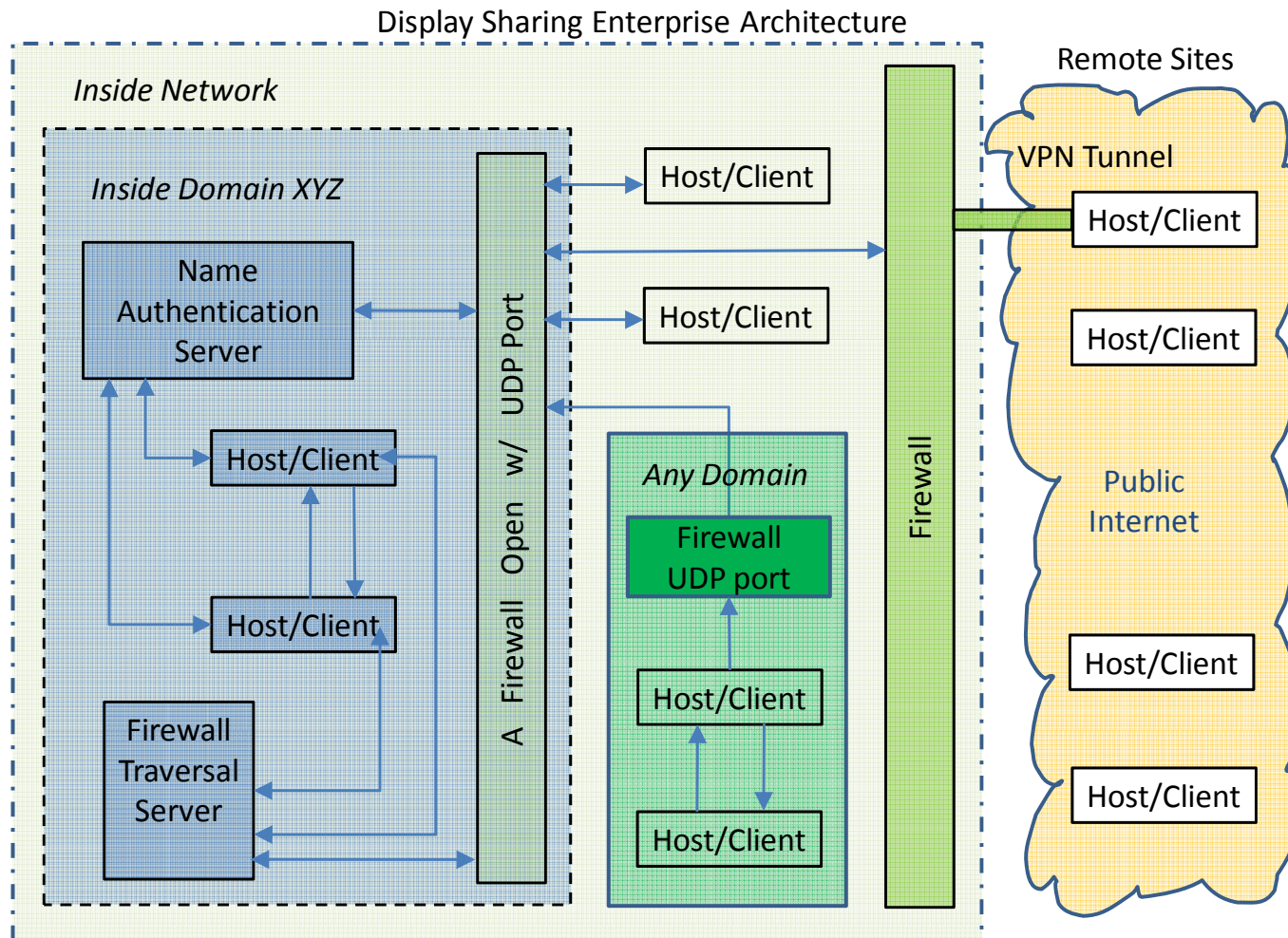[5] Windows-based only (Windows Server to Windows clients only)

Selection Process

- Another OTF study selected the remote access transportation process as the Linux-to-Windows solution.

- A Video Conference product focusing on high end user experience was chosen to develop a prototype for the Windows-to-Windows Solution
  - Highly secure encryption process
  - Very low usage of network bandwidth
  - Required minimal workstation CPU resources
  - Authentication Server to collect member authorization
  - Relay Server to traverse through network firewalls

Selection Process

Inside Network

Inside Domain XYZ

Name Authentication Server

Host/Client

Host/Client

Firewall Traversal Server

A Firewall Open w/ UDP Port

Host/Client

Host/Client

Any Domain

Firewall UDP port

Host/Client

Host/Client

Firewall

Remote Sites

VPN Tunnel

Host/Client

Host/Client

Public Internet

Host/Client

Host/Client

Selection Process

- ## Additional security benefits include:
  - Owning the Sharing process (No web-subscription required)
  - Capable of working with Active Directory that is port configurable through either UDP, TCP or SSL.
  - Capable of working with Relay Server that is port configurable through either UDP, TCP or SSL.
  - Supports single sign-on authentication for minimal group permission issues.
  - Encrypted Solution
  - No File Sharing / File transfer
  - No Video or Audio specific packets are sent
  - Collaboration annotation efforts are sent via pixel-to-pixel process
  - Remote Control is available if desired
  - Host must be actively participating in sharing process. Sharing is suspended while screensaver is active.

Summary

	Favorable Actions	Unfavorable concerns
Ease of Operations	A simple GUI provides the appropriate push / pull model processes.	No user feedback mechanism is in place.
Configuration Setup	Users are automatically authenticated using local Active Directory.	Some products require root access to download.
Security	Encryption over Peer-to-Peer using UDP / TCP / SSL Relay Server for firewalls.	Offsite tactics may require VPN traversal, which will slow performance.
Group Membership	Some products do display both active and non-active participants.	Some do not use all of the authentication features within an active directory.
Sharing Displays to different O/ S	Some maintain all of the last decade of Windows support.	Not very many applications support both Linux / UNIX and Windows.
Manipulating the existing display	Annotation or whiteboard features allow the host and client to collaborate.	Action buttons, erase features and color palettes behave awkwardly. No storage or playback features.
Communication protocol	Some Broadcast features are controlled by a password for a dozen or so interactive clients.	Most do not support a true multicast for a few hundred clients. Security wishes for disable function.

Summary

	Favorable Actions	Unfavorable concerns
Scalability from client to client	Few products feature a host remotely changing the size and placement for sharing with clients.	Multiple monitors should be included within the Desktop real estate.
Recording / Playback	Some products do include the ability to record and playback.	Most products do not support this feature.
Application vs. Desktop Sharing	Applications or desktops can be selected for sharing. Most select from a list of available applications.	Most products dictate the desktop sharing function by presenting the primary monitor only.
System Administration functions	Some demonstrate network statistics, shared connection statistics, and logged messages.	Most do not provide a significant factor to group specific individuals of an Active Directory listing.
Performance	Through some pixel adjustments, bandwidth and CPU consumption can be quite low.	Not recommended for raw video sharing, although coupled with performance accelerator may.
License & Cost	Site-wide licenses can be cost effective with a yearly maintenance cost.	Some providers are rather expensive for the yearly costs.
Inactive Host Sharing	The ability to stop the sharing process while the host is screen locked or has power savings.	Some customers would like the sharing process to continue 24 / 7 without resynchronization issues.

Summary

- OTF is continually investigating and developing the Windows-to-Windows prototype with user feedback Some limitations include:
    - No Linux / UNIX or Apple support available
    - No multicast process for a one-to-many broadcast
    - Some Windows application functions can bleed into Host controlled real estate, and would require Windows tooltips to minimize undesired sharing artifacts.
    - Application sharing can be halted by obstructing applications and may require an additional feature to inform the client (obstructions may offer no updates to shared real estate).
    - Third party Performance Accelerators can hinder sharing process.
    - Collaborative "Action Buttons" can be a real estate nuisance.
    - May want to directly incorporate Active Directory functions as a mechanism to provide Export Control compliance.

Conclusion

- Few products can satisfy all requirements.

- A prototype was developed and shared throughout the JSC community with various customers.

- Proving and demonstrating quick, efficient and cost effective concepts of Display Sharing to the JSC community has provided invaluable information.

- Pixel-to-pixel movement or pixel interpretation allows the client to not be so reliant upon a specific application that delivers graphical updates.

- A Linux-to-Windows remote access session coupled with the Windows-to-Windows display sharing product can be considered an alternative method for the JSC community with thought provoking options and successful collaboration via shared displays.

Questions