MILITARY AND CIVILIAN APPLICATIONS OF VIRTUAL CO-LOCATION AND COLLABORATIVE ENVIRONMENTS AND ASSOCIATED TECHNOLOGIES

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ABSTRACT

There is a growing interest and need to establish and deploy virtual co-location and collaborative environments in which individuals and groups can interact with each other remotely and in real-time. Today's desktop videoconferencing technology does not provide all the necessary components and the flexibility needed to design, integrate, and establish multi-point, multi-platform, inter-enterprise collaborative environments in an economic and efficient manner. This paper presents a summary of our efforts and experiences in designing, integrating, establishing, and evaluating virtual co-location and collaborative environments using today's existing desktop videoconferencing tools and products from a variety of sources.

I. INTRODUCTION

Virtual co-location and collaborative environments are comprehensive solution sets that remove the communication obstacles of global collaboration by offering a variety of interactive and visual tools to create, capture, present and communicate information in the most effective way possible. Ideally, these collaborative environments would enable the conferees to use and manipulate various communication objects and networked components such as audio conferencing, video conferencing, video multicasting and broadcasting, shared electronic whiteboards, shared application execution, document annotation, file transfer, chat, address book, touch-sensitive presentation devices, etc., in an interoperable and seamless manner. Today's desktop videoconferencing technology does not provide all the necessary components and the flexibility needed to design, integrate, and establish multi-point, multi-platform, inter-enterprise collaborative environments in an economic and efficient manner. This paper presents a summary of our efforts and experiences in designing, integrating, establishing, and evaluating virtual co-location and collaborative environments using today's existing desktop videoconferencing tools and products from a variety of sources.

We have concentrated on three common collaborative situations arising in commercial, educational, government, and military domains. Each of these three situations have their own unique and distinct characteristics which result in different implementation requirements in terms of computing platforms and communication technologies. In the commercial domain, these three situations represent the following scenarios: [1] Collaborative environment for use by corporate executives; [2] Collaborative environment to support virtual co-location of multiple software and hardware development teams within a multi-location corporation; [3] Collaborative environment to be used for program management and engineering design of a multi-enterprise system integration project. In the military domain, these same three situations can represent the following scenarios: [a] Collaborative environment for use by military high-commanders; [b] Collaborative environment for use between base-level military technical teams and government contractors; [c] Collaborative environment to be used for command and control of a multi-force or multi-nation joint tactical operation.

Since seamless interoperability is key in successful deployment and efficient use of such collaborative environments, our studies and experimental setups have included a wide range of desktop hardware computing platforms which are commonly found in today's workplace. In particular, our experiments have included PC/Windows, Macintosh, and various flavors of UNIX workstations (e.g., SUN, HP, IBM, SGI). We have also studied and investigated the interconnectivity requirements of collaborative environments in terms of availability and appropriateness of various communication technologies. In particular, we have experimented in designing and establishing such environments via a variety of communication technologies and network connectivity solutions including legacy LANs (Ethernet and token ring), advanced LANs and switching technologies (ATM, switched Ethernet and fast Ethernet), and wide area point-to-point connections (ISDN and leased lines).

The rest of this paper is organized as follows. Section 2 contains our definition of virtual co-location and collaborative environments and how they might differ from the traditional room video conferencing environments. In Section 3, we refer to the key audiovisual and multimedia

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standards which are relevant to collaborative environments and desktop videoconferencing. The three specific collaborative situations which we have concentrated on are described in Section 4. Section 5 contains a brief description of our networking and computing testbed which was used to implement, experiment with, and study various collaborative situations.

II. COLLABORATIVE ENVIRONMENTS

In this section we define what we mean by Collaborative Environments and how this differs from traditional room-based videoconferencing facilities.

The traditional room-based videoconferencing systems are generally characterized by a collection of dedicated videoconferencing rooms which are equipped with video teleconferencing (VTC) terminals and are interconnected by means of private and/or public wide-area telecommunication services. These systems generally enable a number of people at different sites to take part in remote conferences where conferees can hear (audio component) and see (video component) each other. Although these traditional room-based videoconferencing systems still serve a purpose and are being used by a large number of organizations, they have a number of shortcomings when used in today's computer-based work environments. Some of the major shortcoming and disadvantages of the traditional room-based videoconferencing setups are:

- Typically they only support audio and video conferencing.
- There is no native vehicle for exchanging documents and viewgraphs. Exchange of documents is typically achieved by either faxing a hard copy of the documents ahead of time to all remote sites or employing additional cameras and monitors to act as document viewing mechanism.
- Conferees have to leave their normal place of work and go to a special videoconferencing room.
- Reservations must be made for the use of the videoconferencing rooms at each site ahead of time.
- Scheduling and coordination must be made with all conferees at all sites.
- Arrangements might have to be made ahead of time with local and/or interexchange carriers for connectivity services.
- A telecommunication carrier operator might have to get involved at the time of the conference establishment. This is particularly true for multipoint conferences.
- These systems are typically not portable. Although rollabout versions have been available for years, they still require fixed special communication facilities in each room which the unit is to be rolled to.
- They are expensive to establish.
- They only support a very limited set of communication networks and services for connectivity.
- They are often not based on open and scaleable standards and solutions.

However, today's modern computer-based work environment often requires individuals to work together across distances using the power of their personal computers, to not only see and hear each other, but also to share various forms of information and to collaborate on various objects remotely. It is this type of environment that we refer to as a "Collaborative Environment" in this paper. We define a collaborative environment as having all or many of the following characteristics:

- They are designed to provide an integrated audio/video/document/data/application sharing and collaboration.
- They are comprised of a multiplicity of components such as: audio, video, electronic shared whiteboards, real-time shared applications, touch-sensitive panels, file and data transfer, annotation tools, data and screen capture, chat capabilities, etc. etc.
- Conferees can utilize it from their desktop computer without the need to going to a specialized room.
- They can be implemented via the same desktop computer that individuals use for their day-to-day activities such a email and text processing.
- They are cheaper to set up per person compared to traditional room-based systems.
- They can be implemented via a wide range of network connectivity options.
- They can easily be made portable.
- They are now often based on scaleable and open standards and solutions.

The fundamental difference between the collaborative environments, as defined here, and the traditional videoconferencing systems is the "data." It is the capability of sharing and collaborating on various forms of electronic information and data that makes collaborative environments valuable and attractive. It should also be noted that although collaborative environments provide many more capabilities compared to traditional videoconferencing solutions, they should not be viewed as a full replacement for today's room-based group videoconferencing settings.

Some of the key benefits and promises of collaborative environments can be characterized as follows:

- They provide the conferees the capability of manipulating various communication objects and networked components beyond just audio and video capabilities.

- They provide comprehensive solution sets that remove many of the obstacles of global collaboration by offering a variety of interactive and visual tools to create, capture, present, and communicate information in the most effective way possible.
- They provide conferees access to much more than what can be carried into a conference room or what can be fit into a briefcase.
- They enable world-wide access to remote and scarce expertise.
- They facilitate real time interactions and decision making.
- They enable better and quicker responses to customer needs.
- They provide the capability of responding to unpredicted requests.
- They extend the capability of existing communications infrastructure and conferencing equipment into a future of PC-based communications.
- They lead into increased productivity and efficiency, and in some cases, reduced costs.

III. AUDIOVISUAL AND VIDEOCONFERENCING STANDARDS

A key aspect of design and implementation of successful collaborative environments is adherence to appropriate open standards. It is now very well understood that international open standards are fundamental and necessary step in the design and implementation of interoperable audiovisual and multimedia communications and networking. It is, therefore, important to be aware of and follow all relevant standards related to various components of collaborative environments as described in [1,2].

IV. THREE COLLABORATIVE SITUATIONS

Our main objective has been to investigate the design, integration, demonstration, and evaluation of multi-point, multi-platform, inter-enterprise virtual co-location and collaborative environments. In addition, we have been interested in establishing and demonstrating a generalized desktop videoconferencing environment built upon open standards and commercial off-the-shelf hardware and software components utilizing a wide variety of network connectivity options.

In achieving our objectives, we have concentrated on three common collaborative situations arising in various domains such as commercial, educational, government, and military. The genesis of these three specific situations are embedded in our internal and external customers' desires for reducing mission planning and development cycle times. We define these three collaborative situations by means of the following commercial and military scenarios:

1. Collaborative environment for use by:
   a. corporate executives, or
   b. military high-commanders.
2. Collaborative environments to support virtual co-location of multiple software and hardware development teams:
   a. within a multi-location corporation; or
   b. between base-level military technical teams and government contractors.
3. Collaborative environment to be used for:
   a. program management and engineering design of a multi-enterprise system integration project.
   b. command and control of a multi-force or multi-nation joint tactical operation.

In the rest of this section, we further describe each of these three situations and summarize our experiences with establishing and evaluating each.

A. Situation 1

In the commercial domain, this situation models the interactions between two high-level corporate executives from different enterprises such as presidents or chief executives of different corporations. These scenarios often involve one or two individuals at each distant site. The individuals involved are often non-technical and topics of discussions are often high-level and business related. The same situation also arises within the a multi-location enterprise where, for example, a single chief executive of a corporation holds "eye-to-eye" virtual meetings with each of the general managers of various sites. In the military domain, this situation models distant interactions between a small number of high-level military officials such as generals and admirals. Again, these scenarios often involve only one or two military commanders at each distant location and the discussions are often related to high-level military planning.

We have experimented with this situations by integrating necessary hardware and software components into desktop computers of a number of our own executives at such locations as New York City (NY, USA), Owego (NY, USA), and Portsmouth (United Kingdom). Our key observations and recommendations for establishing this type of collaborative environments are summarized as follows:

- The audio and video components are the most important components for this type of collaborative environments. The users and conferees are mostly interested in hearing and seeing each other.
- Electronic whiteboards are of lesser importance to the users of this type of collaborative environments.

- Other components, such as real-time application sharing are not considered necessary by the users of this type of collaborative environments.
- Audio and video quality are considered very important. The users expect the same audio quality as they are used to with the standard telephone system.
- The user-friendliness of the entire environment is very important to the users. This is particularly important since this type of collaborative environment if often used by individuals who might not be interested or might not have the time to learn to operate a rather complicated system. In other words, the environment must be trivial to use.
- Because of the expectation of its users, the implementation must be very reliable.
- The real users are often assisted by their administrative assistants in establishing connections and initiating calls.
- The most common uses of this type of collaborative environment include: virtual interactions between peer executives at different enterprises; corporate planning discussions between corporate headquarters executives and executives at other corporate locations; high-level customer contacts; etc.

B. Situation 2

In the commercial domain, this situation models a number of scenarios which are increasingly becoming common place in today's high-tech environment where multiple small technical teams are involved in design and development of high-tech products. Examples of such scenarios are collaborative situations where multiple teams of software developers, located at different sites within the same enterprise, are collectively developing different software components of the same system, or multiple teams of design engineers, from different companies, are collectively working on a common engineering task. Similar scenarios are increasingly occurring in the military domain where more and more base-level military technical teams are required to work very closely and collaboratively with teams of engineers and software developers from commercial firms performing on high-tech military contracts. Regardless of the domain (commercial, educational, military, etc.), this situation is characterized by virtual environments were multiple groups of technical individuals located at distant sites are collaboratively working and cooperating on a single common technical task.

In addition to our laboratory and testbed experiments and evaluations, our conclusions regarding this collaborative situation are based on two separate collaborative environments that we have designed and help implement between two of our engineering teams and their respective counterparts in different military environments. Our key observations and recommendations for establishing this type of collaborative environments are summarized as follows:

- Audio, shared whiteboards, and real-time application sharing are the most important components throughout the conference and collaboration.
- Often the video component becomes less important after the first 15 minutes of the conference.
- Audio quality is very important.
- Video quality is not as important; the participants were satisfied with lower video quality than those required by the participants in the previous situation.
- Performance of the data sharing components (e.g., electronic shared whiteboards, real-time application sharing) are very important.
- LAN-based solutions are more attractive to the end-users when the distant teams are within the same enterprise and have clear (i.e., no firewalls) TCP/IP connectivity between their respective LANs. LAN-based solutions are mostly impractical today when the distant teams are part of different enterprises which do not have a common network infrastructure. ISDN-based solutions are the primary vehicle for inter-enterprise teams today.
- Network and system security becomes an issue for inter-enterprise teams where access must be strictly limited to the network resources related to the common task.

C. Situation 3

This collaborative situations is best characterized by virtual conferences involving multiple teams of technical individuals as well as non-technical teams such as program managers and financial personnel. In the commercial domain, this situation models the interactions between multiple teams of engineers, project managers, financial personnel, and customers located at different sites, working and cooperating on a vary large system integration project. The discussions are often a mixture of technical, program management, financial, contractual, and scheduling topics. They often involve multi-point conferences with several individuals at each end-point. This is one of the most difficult collaborative environments to implement successfully today. This is due to a number of reasons such the fact that it involves both highly technical individuals and not-technical personnel, and that it is often involves multi-point inter-enterprise calls. Very similar situations arises in the military domain, for example, in dealing with the establishment of a virtual command and control infrastructure for a multi-force or multi-nation joint military operation. Such situations often involve multiple

teams ranging from high military officials, to military planners, to field commanders, and soldiers are collaborating on both high level military strategies and detailed execution plans. Our key observations and recommendations for establishing this type of collaborative environments are summarized as follows:

- Audio, video, and shared electronic whiteboards are the most important components throughout the conference.
- The capability to remotely and collaboratively flip through a set of presentation charts or set of spread sheets is very important.
- Real-time shared application capability becomes important when, for example, the technical team needs to remotely demonstrate a newly developed software component to the customer.
- The user-friendliness and the reliability of the system is important as it was for the first situation above.
- Often it involves inter-enterprise conferences and, therefore, pure LAN-based solutions are not sufficient and network security is important.

V. NETWORKING & COMPUTING TESTBED

Today's commercial of-the-shelf desktop videoconferencing products do not provide all the necessary components and the flexibility needed to design, integrate, and establish multi-point, multi-platform, inter-enterprise, interoperable collaborative environments. We have, therefore, studied, tested, and experimented with a large number of such products in our multi-platform, multi-operating system, multi-network testbed. Since seamless interoperability is key in successful deployment and efficient use of such collaborative environments, our studies and experimental setups have included a wide range of desktop hardware computing platforms which is commonly found in today's workplace. In particular, our experiments have included PC/Windows, Macintosh, and various flavors of UNIX workstations (e.g., SUN, HP, IBM, SGI). We have also studied and investigated the interconnectivity requirements of collaborative environments in terms of availability and appropriateness of various communication technologies. In particular, we have experimented in designing and establishing such environments via a variety of communication technologies and network connectivity solutions including legacy LANs (Ethernet and token ring), advanced LANs and switching technologies (ATM, switched Ethernet and fast Ethernet), and wide area point-to-point connections (ISDN and leased lines). Table 3 shows a sample of the products that we have dealt with in our testbed.

	Computing Platforms						Connectivity		
Products	**SUN UNIX**	**HP UNIX**	**IBM UNIX**	**SGI UNIX**	**PC Windows**	**Apple MAC**	**ISDN**	**Ether-net LAN**	**ATM LAN**
ShowMe (SUN)	X							X	X
InPerson (SGI)				X				X	X
Communique (Insoft)	X	X	X	X	X			X	X
Vistium (AT&T)					X		X		
ProShare (Intel)					X		X	X	X
ERIS (RSI)	X				X	X	X		
CuSeeMe (Cornell)					X	X		X	X
Etc., Etc., Etc.									

Table 1 - Sampling of Products and Configurations Tested and Experimented

VI. REFERENCES

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