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Vartalaap: A Network Based Multimedia Presentation System

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Abstract

Vartalaap is a hierarchical distributed system for multimedia communication over a LAN, implemented to provide an environment that closely approximates a classroom, where interaction, in the form of text, graphic images and voice is two way. This paper presents some details of Vartalaap with a special reference to its support for multimedia based 2-way interaction between a "Presenter" and a "group of participants". The Presenter and the participants may be situated anywhere, as long as they are connected through a LAN. Users access the system via a workstation which has "good" graphics capabilities and built-in support for audio. Issues covered in this paper include an overview of a presentation scenario which Vartalaap models, User's view of Vartalaap, System's view of Vartalaap, and Vartalaap protocol. A status report on the current implementation of Vartalaap is also given, along with its comparison with some other systems. We conclude with a discussion on the limitations of the current implementation and directions for future work.

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1 INTRODUCTION

Recent advances in networks and workstation technologies have opened up avenues for range of applications which use multimedia communication. Workstations are available which have good graphics capabilities, built-in support for audio and in some cases built-in support for video. There are many organizations which have clusters of such machines that are connected by a network, whose quality (in terms of reliability and bandwidth) is improving day by day. All these have lead to development of various systems like distance-learning systems, group decision support systems; all of which come under "groupware" or "computer supported cooperative work (CSCW) "[Engelbrat, 1988; Kling, 1991; Grudin, 1991; Bui *et al.*, 1986]. Applications like teleconferencing, co-authoring systems, telemarketing, teleshopping are typical examples [Watabe *et al.*, 1991; Robinson *et al.*, 1991].

Distance learning systems [Elmore, 1992] provide a boost to community education programs by opening up avenues to a vast cross-section of society. In large countries like India, with shortage of experts in various fields, this technology can help to provide the services of few experts to wide range of people for training and education in thrust areas such as Medicine, Software Engineering, etc. Computer based distance learning systems differ from the conventional video-based and TV-broadcast programs in that the former allows a higher level of user interaction. To be effective such systems need a good support from networks to carry multimedia traffic and from workstations to present multimedia data in real-time. In this paper, we present one such system, which is basically a network-based multimedia presentation system called Vartalaap. This is a hierarchical distributed system for multimedia communication over a LAN, implemented to provide an environment that closely approximates a class room, where interaction, in the form of text, graphic images, and voice data is two-way between a "Presenter" and a "group of Participants". The presenter and participants may be situated anywhere, as long as they are connected through a LAN. Users access the Vartalaap system via a workstation which has good graphics capabilities and built-in support for audio. It can be easily seen that this system can be used to

1.improve quality and availability of trained manpower.

2.conduct user-friendly and cost-effective group discussions on products/topics of interests. and

3.undertake computer supported cooperative work.

We assume that the required bandwidth for such applications would be available to the system.

Vartalaap relies on some of the ideas/concepts reported in [Lashkari *et al.*, 1993; Robinson *et al.*, 1991; Wallace, 1991; Little *et al.* , 1990; Elmore, 1992] and has various features such as the following :

•The system runs as an application under the well known client-server paradigm.

- It ensures the avoidance of broadcasting by using multicasting at software level . This is acheived based on ideas reported in [Lashkari *et al.*, 1993].
- The system allows multimedia based interaction between presenter and participants in a WYSIWIS (What You See Is What I See) mode.
- It takes care of synchronization constraints across different media types, using event based synchronization approach.
- It compresses both image data and audio data before transmitting over the network.
- It supports both monochrome and color (8-bit or 4-bit) displays and also allows them to talk to each other.

The rest of this paper is organized as follows. Section 2 provides an overview of a presentation scenario which Vartalaap models. Section 3 is devoted to the proposed system along with how this system provides all major functionalities required for the presentation environment. It also includes a brief overview of important packet-formats. Section 4 gives a status report on the current implementation of Vartalaap, along with its comparison with some other systems. Conclusions and future directions are given in the last section.

2 AN OVERVIEW OF A PRESENTATION SCENARIO

Let us first examine what all is involved in a real-life class-room based presentation to a group of students. A presentation of this type would consist of the following objects :

- **Presenter** Presenter is the person who is holding the floor and making the presentation to a class. The whole session would be mostly dominated by the Presenter. He/She also has control over various other objects such as projector, slides etc.
- **Other Participants** All other persons in the class participating in the presentation, are mostly passive. They listen to the Presenter and do not have much control over most of the objects involved. They can however interrupt the presentation to make queries or seek clarifications, and at times can also be given control of certain objects with permission from the Presenter.
- **Projector and Screen** The Projector and Screen together are used by the Presenter to project slides in aid of the topic in discussion. These objects are usually controlled by the Presenter.
- **Slides** The image information is stored in the form of transparencies(referred to as slides, henceforth in the paper). The Presenter owns a set of slides which he/she projects on the screen using the overhead projector. The Presenter can replace or overlap slides.

He/She can mark over slides, point out on the slides or can scribble notes over it using marker pens.

- **Marker Pens** As mentioned above, these objects are used by the Presenter for online editing of slides. These are totally controlled by the Presenter.
- **Pointing device** This object is used to draw the attention of the participants to particular part of information on the projected slide or whiteboard. This is also controlled by the Presenter.
- **Whiteboard and pens** In any conventional presentation environment, there is a common whiteboard over which usually the Presenter can write/draw using pens/chalks. This writing/drawing is visible to all participants in an online fashion.(i.e. while it is done).
- **Microphone and Speaker(s)** The audio media support would be provided through these objects. These objects are not absolutely essential though, as in a small place, one might do without it. However, for the sake of generality, we have included these objects. The microphone is totally under the Presenter's control, but can be passed onto a participant on request; the speakers may or may not be under the control of participants.
- **Video player** Some presentations also rely on video players using which the Presenter can show video clips (e.g. pre-recorded ones). This object is again controlled by the Presenter and the clips shown are visible to all participants.

Many other objects (for example, a video camera) are also used in different Presentation environments. However, in most cases, only objects mentioned above are used.

The various media used during a real-life presentation would be :

- Text : Using whiteboard or slides, the Presenter can communicate through text medium.
- Images/Graphics : Images could be shown using prepared slides and projecting them during presentation.
- Audio : Audio medium is the most natural medium in which the Presenter would communicate. Participants would also use this medium to interrupt and seek clarification.
- Video : Presenter might use this medium through video player to aid the topic of discussions.

3 VARTALAAP: A PROPOSED SYSTEM

The presentation scenario described in Section 2 has all the participants and the Presenter located at one place. Consider a variant where they are situated at different locations. Vartalaap attempts to model this new variant as closely as possible to enable users to have

a "presentation" over LANs through their workstations, using text, images/graphics and audio media. A workstation is assumed to be equipped with "good" graphics capabilities and built-in support for audio.

3.1 User's View of Vartalaap:

Here we describe Vartalaap from the user's point of view and indicate how the various objects as listed in Section 2 are realized in our system. Presenter is a user with special privileges. In Vartalaap, whosoever starts the presentation using his/her workstation, becomes the Presenter. Presenter provides information on the content of presentation and its duration. Many such "Presentations" can be in progress at the same time. A user, if desires, can participate in all the "Presentations" in progress. He/She can become a participant by "joining" any of them at any time.

Each Vartalaap user gets an X-Windows [Scheifler *et al.*, 1991] based WYSIWIS(What-you-see-is-what-i-see) interface which is easy to learn and use. The interface (see Figure 1) is logically divided into following sections :

- *The Information Section:*

  This section has a window which displays the participant's photograph and some personal information such as his/her name. It also shows if the participant is currently having control of pen or microphone, using icons.

- *The Text Subwindows:*

  There is a subwindow for each participant in which he/she is allowed to key in text. This appears on every user's monitor.

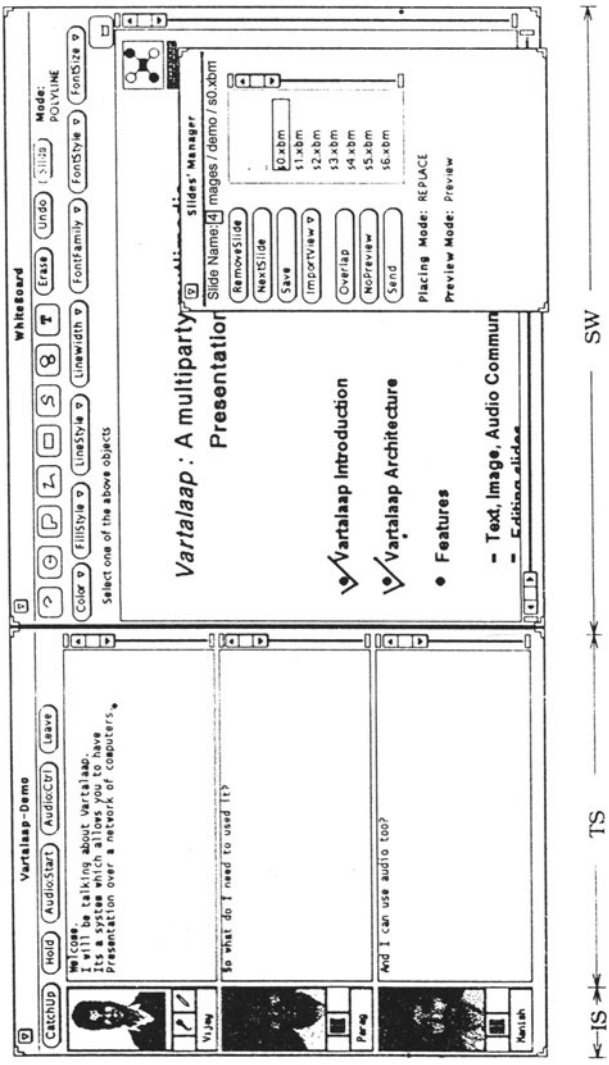
- *The Shared Whiteboard:*

  This window provides a common area for all participants. This area can be visualized as a whiteboard as well as a screen mentioned in Section 2. There is a common pen controlled by the Presenter. Any participant can get the pen with permission from the Presenter. A participant holding a pen can use this common area to draw graphics, write text, load pre-stored images (slides) or cut and paste from his/her screen.

- *The Control Panels:*

  The interface has two major sets of control panels. A generic control panel for each Presentation, and a panel specific to the shared whiteboard. The generic control panel (see Figure 2) has a set of buttons which allow a participant to "CatchUp" if he has joined late, freeze the presentation for some specified time (on permission from the Presenter) using "Hold", "Leave" the presentation, and activate the audio control panel. Audio control panel allows the participant to control the record gain, play volume, and output device (speakers or jack) of the local audio device.

  The whiteboard control panel (see Figure 3) has a set of drawing tools. They allow participants to generate graphics, text and do annotations on the whiteboard. In most



IS : INFORMATION SECTION

TS : TEXT SUBWINDOW

SW : SHARED WHITEBOARD

Figure1: The users view of Vartalaap

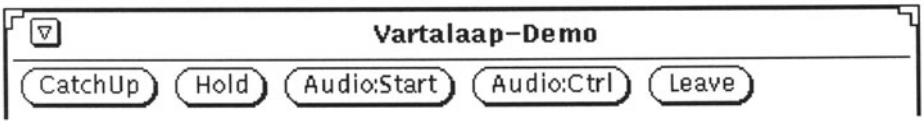


Figure 2: Generic Control Panel

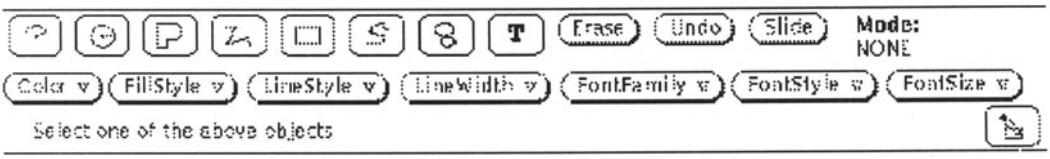


Figure 3: WhiteBoard Control Panel

of the buttons we have avoided using text-strings but have used pictorial representation in order to make the interface easily internationalizable. As the text-strings are used minimally, the language barriers need not deter the user from using the system.

A Slides' Manager panel can be activated using the "Slide" button. Slides' Manager allows to load, overlap, remove or save slides from the whiteboard. The Presenter is assumed to have a repository of slides which would aid him/her during presentation. Slides are represented as images stored as standard graphics-format files. A Slides' Manager Window on the display monitor of the Presenter shows the stack of slides to be used during the presentation scheduled. A marker indicates the slides already displayed and the slide which is next in the queue.

In Vartalaap, each workstation is assumed to have microphone/speakers. However, microphones or Audio-input devices are made totally controlled by the Presenter because of obvious reasons. On the other hand, each participant has been allowed to have control over his/her own speaker (audio-output device). Presenter can speak using his/her workstation's microphone, which is transmitted and played on the speakers of all participants.

3.2 System's View of Vartalaap:

Before giving the design of the system, we give the list of some important goals which motivated such a design. We aimed at having a system such that

•Broadcasting of messages over the network should be avoided.

•System should be run in user mode.

•It should provide support for continuous media like audio and video.

•It should be independent of the type of communication network.

•Users should be able to run the system on easily available popular kind of workstations.

•It should be robust and extensible.

•Users should be able to start using the system after a short demonstration.

In the following sections we will give the internals of Vartalaap system and discuss various design issues.

3.2.1 The System Architecture

Vartalaap uses the well known client-server paradigm. It runs over the Transmission Control Protocol/Internet Protocol (TCP/IP) stack in a LAN environment[Comer, 1991; Stevens, 1992]. Figure 4 shows the Vartalaap's architecture. The system consists of a presentation manager (server) which manages the whole system, and the user-end program - Vartalaap (client) connects to this manager. Both presenter and participants are clients to the presentation manager. To make the server more robust, we have a backup (or mirror) server which mirrors the active server. In case of server failure, the backup server takes over. This happens without the user's intervention.

3.2.2 The Vartalaap Protocol :

Vartalaap follows a simple byte-stream protocol between client and server. The protocol consists of request, reply, error and data packets. (See Figure 5 for few sample packet formats). The first field of each packet identifies the type of the packet. The remaining fields are specific to the packet type. The request and reply packet contains the requests from the clients and the replies from the server respectively. Each data-type is first packetized before sending. The data is put in data packets. Figure 6 gives the basic data transfer algorithm which involves preparing text, image and audio packets. The error packets are generated to indicate invalid requests or abnormal conditions.

3.2.3 Server internals

The presentation manager acts as a server, continuously listening at a well known port. The various functionalities of the server are as under

•Maintain the information of current presentations.

•Maintain the list of participants in each presentation.

•Route the data to appropriate nodes.

•Maintain archives of the information transferred and provide "history" on request. User may generate a "CatchUp" request when they join in late. In response to this request, the server sends the history data.

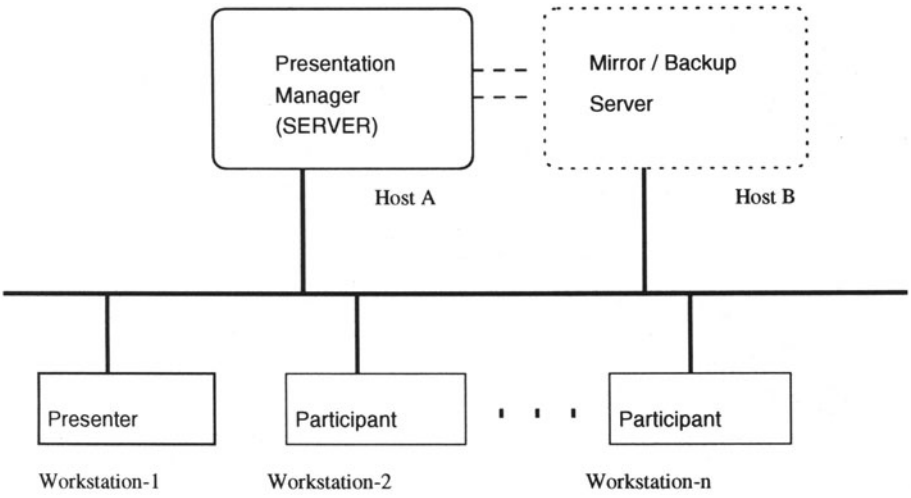
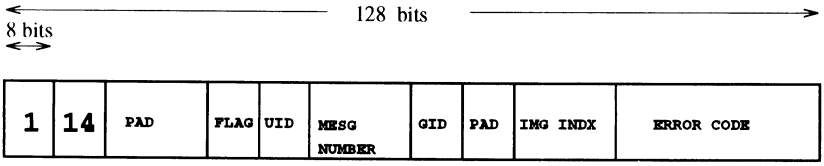
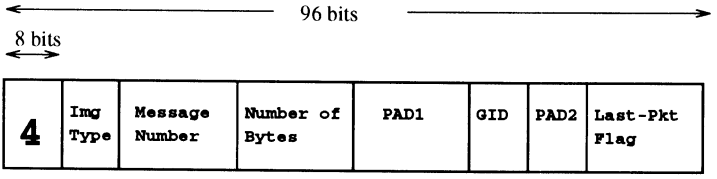


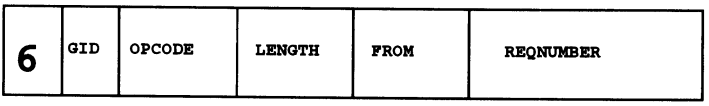
Figure 4: System Architecture



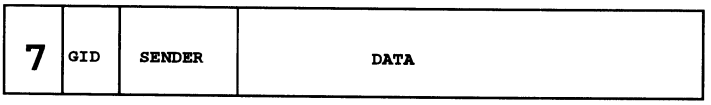
A. Make-Group Reply Packet



B. Send-Data Request Packet



C. Error Packet



D. Data Packet

Figure 5: Sample Packet Formats

Text packet Transfer

Repeat

Read in the text data

Form the text packet (as shown in fig. 5) with group identifer and message number fileds set.

Write the packet to the text channel.

Until end-of-text-data.

Image packet Transfer

Repeat

Read the image file contents in a buffer.

Determine the image type and compress using appropriate compressor.

Divide the compressed data into fixed size packets (4K bytes currently).

Form the image packets. Set the image header, with image type , group identifier, last-packet flag values set.

Write the packet to the image channel.

Until end-of-image-file

Audio packet Transfer

Repeat

Read audio data from the audio device and store into buffer.

Do a silence detection. If silence then update the silence gap cntr and go to start of the loop.

If non-silence data, then form the audio packet.

Put a time-stamp. Set other header fileds like group identfiers, previous silence gap.

Set the silence gap count to zero.

Write the packet to audio channel.

Until end-of-audio-data.

Figure 6: Pseudocode for Data Transfer Algorithms

•Serve various other client requests. Clients generate various other miscellaneous requests like "Hold" or "PenRequest" which are to be appropriately served.

It may perhaps be noted that a lot of book-keeping is done by the server and hence the machine running as server should be a powerful one.

3.2.4 Client internals

The presentation client (Vartalaap) is the one which is visible to the user. It can be viewed in terms of two separate layers : The lower layer which communicates with the server and the upper interface layer which provides an intuitive interface for users. The lower layer is written using the set of primitives provided in the Vartalaap library similar to one in [Lashkari *et al.*, 1993]. The client functionalities can be grouped as under

•Allow users to join or start a presentation.

•Allow participants/presenter to leave a presentation.

•Allow participants/presenter to transfer and receive text/image/audio/video data.

•Provide convenient way of generating requests for server. This has been discussed in the Section 3.1 , which gives the User's View of Vartalaap.

3.2.5 Images and Compression

The slides presented by the Presenter are assumed to be in some standard graphics format. The XBM, GIF, PPM, JPEG [Wallace, 1991] are the formats available. Image files (slides) tend to be large. Hence to save on bandwidth, it is desirable to compress the image data before transmitting over the LAN.

Vartalaap compresses the image files depending on their formats (all those mentioned above are supported). Monochrome XBM files are compressed using standard unix compress, which compresses up to 10-30% depending on the content of the image. The color images (GIFs/PPMs) are compressed using the JPEG compression algorithms to achieve compression up to 10% (PPM files) to 30% (GIF files). Images are packetized into smaller chunks and sent over the network. These packets are reassembled at the recipient end.

Vartalaap supports both monochrome and color (8-bit or 4-bit) displays and also allows them to talk to each other. The necessary conversion of depth of the image is done at the recipient end. Color images are ditherized and shown on monochrome displays. On 8-bit color displays, all available colors are preallocated using 6:6:6 palette. Of course this would not reproduce the closest colors, but since we allow overlapping of slides, we could not keep dynamic color allocation[Scheifler *et al.*, 1991].

3.2.6 Audio transmission

Audio data is known to be very bulky. On SunSparcs with 8-bit u-law encoding , we get around 500Kbytes of data generated every minute. Transmitting such a large amount of data would flood the LAN . In order to control this situation in Vartalaap, we have encoded

silence into non-silence audio data and transmitted only this encoded form. Audio data is also packetized and sent with time-stamps which help in synchronization.

3.2.7 Synchronization between various media:

Synchronization is an essential requirement in systems supporting a mix of time dependent and time independent data which are subjected to random delays as they travel over the network. In Vartalaap, we use a simple mechanism for this, which works without making any assumptions about underlying network or operating system. The time sequence between audio, image and text data is maintained using this mechanism. All the data is assumed to be generated from live sources, with no prior knowledge about their inter-relationship in temporal domain.

Each client does a coarse synchronization of clock with the server's clock at the start up time. During communication, each packet is tagged with a timestamp generated from local clock (clock of the data source). The recipients buffer the incoming data packets and plays these buffered packets sequencing them as per their timestamps. Thus the temporal relationship between the different streams is maintained.

The critical issue is the size of buffer required to achieve synchronization. We have proposed to determine the buffer size using simulation runs for a given traffic pattern over a live network. This approach is not only different from that in [Little *et al.* , 1990; Little *et al.* , 1991] but also found to be practical! Once the buffer size is determined, it is pre-allocated at each site and we do not require any special algorithm to determine it at runtime.

4 IMPLEMENTATION ISSUES AND RELATED WORK

Vartalaap's current version has been implemented on SunSparc Workstation running SunOS 4.1.1. The workstations are connected by an Ethernet LAN. The current version can be easily ported onto any platform which has good networking support, adequate GUIs, and devices like microphone and speakers.

Unlike some other systems like IRC [Oikarinen *et al.*, 1993], which have a set of distributed servers, Vartalaap has a single central server backed up with a mirror server. IRC, as it has distributed servers, is more fault tolerant. But because of multiple servers the messages may travel through a longer path and hence there is a possibility of unpredictable delays. IRC is text-based system so these delays are tolerable. But in multimedia based systems like Vartalaap , with the multimedia traffic , these delays can not be tolerated. So we opted for a single central server based architecture with a backup mirror server, for Vartalaap. However, in the current version of Vartalaap the mirror server has not yet been implemented.

Vartalaap does multicasting at application level using the ideas reported in [Lashkari *et al.*, 1993]. Extensions are being proposed to support multicasting at IP itself [Deering, 1989] and many systems [Jain *et al.* , 1993] propose to use IP multicasting as a base. However, this requires that all nodes on the network support the particular extension which is not being widely supported yet. Due to this we believe that the multicasting at application level as is done in Vartalaap would be beneficial at this stage.

The current version of Vartalaap supports audio communication via half duplex single audio channel. Such a support is found to be adequate in the class-room presentation scenario that Vartalaap models. But a detailed study is required to be conducted to compare its performance with those systems where multiple audio channels are used [Jain *et al.* , 1993].

Vartalaap provides a single pen for annotating, drawing and editing the slides in the WhiteBoard. Only the holder of the pen can use the drawing tools and make annotations or edit displayed slides. It is required to be explored to use two sets of annotation tools; one for the Presenter and other for the participants [Jain *et al.* , 1993]. In [Robinson *et al.*, 1991] a tray of annotations tools (called pens) are provided. But allowing more than one user drawing at the same time makes it necessary to provide some color code to each user. Vartalaap is designed so that it can work even on lower end monochrome workstations . Hence we have provided a single pen which is controlled by the Presenter. Participants can use it on permission from the Presenter, and this may avoid unnecessary confusion and bring more discipline in the presentation.

In Vartalaap, event based synchronization between different media is achieved by buffering the data at the recipient end and playing as per the timestamps (Section 3.2.7). The buffer sizes required are determined apriori using simulation runs as mentioned earlier (Section 3.2.7). In [?; Little *et al.* , 1991], petri-nets have been proposed to model the temporal relationship between various data types. However, this approach requires real-time support from the underlying operating system, bandwidth reservation capabilities from the network and run time algorithms to determine buffer requirements. The simple approach adopted in Vartalaap has produced satisfactory results on LAN without making any assumptions about the above mentioned requirements.

Because of the fixed size data structures at the server in Vartalaap and the display monitor size, its current version limits the number of participants to be 5, and the number of presentations to be 3. However these numbers can be changed and Vartalaap can be recompiled for use, but there would be no more than five information sections on the monitor at any given time.

5 CONCLUSIONS AND FUTURE DIRECTIONS

The paper has presented a network based multimedia Presentation system. This system has been modeled to handle a class-room type presentation scenario, where more interaction takes place between the presenter and participants. It can be easily seen that Vartalaap has all the features required for video-conferencing and distance-learning on LAN.

The current version of Vartalaap ensures the avoidance of broadcasting, allows multimedia based interaction between presenter and participants in a WYSIWIS mode, takes care of synchronization constraints across different media types, compresses image and audio data and supports monochrome and color displays. Furthermore, this differs from the systems based on ideas contained in [Robinson *et al.*, 1991; Oikarinen *et al.*, 1993; Little *et al.* , 1990; Little *et al.* , 1991; Jain *et al.* , 1993]. An earlier version of the system was placed in the public domain, and the feedback obtained so far has been very encouraging. Some of the suggestions which came out of this feedback, have been incorporated in the version reported in this paper.

Attempts are under way to incorporate the mirror server, multiple audio channels, and the background required for full-motion video. The latter one may require the new version of Vartalaap to run on high speed LANs like FDDI. Furthermore, an exploration is under way towards making Vartalaap suitable for distance education on WAN, using group communication standards. All this will be reported in subsequent papers.

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