ADVISORY GROUP ON
Computer Graphics

A study into Video Conferencing Using the Apple Macintosh Platform

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sima
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Contents

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Chapter 1

Introduction to the Project

This study into the uses of video conferencing on the Apple Macintosh took place between June 1994 and January 1995 at theUniversity of Derby and involved members of the Design Research Centre in the School of Art and Design at Derby, theUniversity's Research Office and the Computer Services department. The goal of the study was to build an understanding of howvideo conferencing can be used to support day-to-day working activities D particularly in a University context.

During the lifetime of the project a number of activities took place. Firstly, we constructed a video conferencing network at theUniversity of Derby using Macintosh multimedia computers and a software package called CUSeeMe. Secondly, we conducted asurvey of a group of video conferencing users with the aim of discovering how video conferencing systems such as CUSeeMe arecurrently being used. Thirdly, we ran a series of 'artificial' (in the laboratory) video conferencing sessions D in which users were askedto use our video conferencing network to work on a number of pre-defined tasks. Next, we allowed a group of office workers to useour video conferencing network to support their work activities for a period of approximately. And finally, we analysed theperformance of the CUSeeMe package whilst varying a number of its functional parameters in order to ascertain it's most efficient operating conditions. Each of these activities is fully reported in this document.

In our conclusion we discuss the lessons learnt from what we feel was an interesting and successful project. Additionally, followingthe official end of the project we have run a number of further activities using our CUSeeMe video conferencing network. The mostelaborate of these being a long-term project which linked art students in Derby with counterparts in Holland via CUSeeMe andreal-time 'chat' sessions. As is also discussed in the conclusion, it is this type of collaborative activity which appears to be particularlywell suited to video conferencing D even at fairly low frame rates. Finally, we introduce our future plans for video conferencing at Derby - including a 'public access' video channel for arts-related activities.

Chapter 2

Video Conferencing on the Apple Macintosh

The Apple Macintosh has a reputation as one of the most easy-to-use computing platforms available, as well as being one of the bestsuited to multimedia applications. Hence, it would seem likely that it would to be an appropriate environment for videoconferencing applications. And indeed this is the case, with a number of Macintosh-based video conferencing software packagesbeing available. In this chapter we look at the components of a video conferencing system and describe how the Apple Macintosh supports video conferencing applications.

The Components of a Video Conferencing System

Any computer-based video conferencing system, be it a stand-alone unit or one based around a desktop computer, contains of anumber of important components. Firstly, there is the video camera, used to capture the image of the user. Then a digitiser, usedto convert the (normally) analogue output of the camera into a digital form. Then a CODEC (Compressor/Decompressor) used tocompress the digital video signal ready for transmission and to decompress incoming video data for presentation on a video/computerdisplay. And finally there is the Network Interface and Hardware D the systems front-end to the computer network that will carry the video data between the members of the video conference. The flow of data between these components is shown in Figure 2.1.

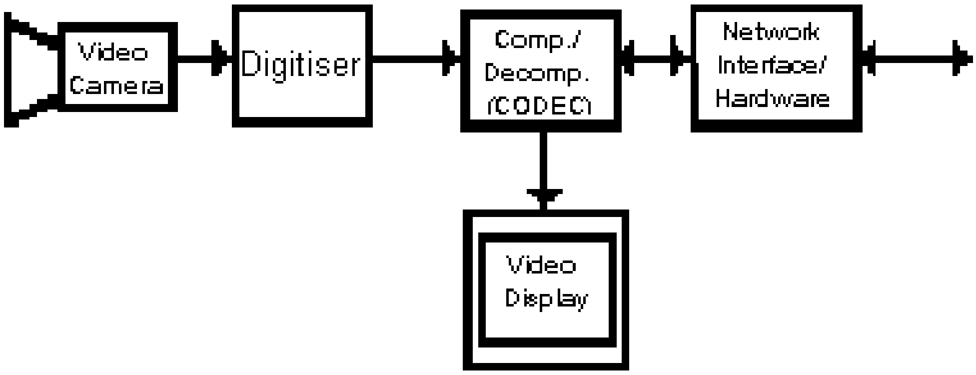


Figure 2.1. The main components of a video conferencing system.

Until fairly recently, the most significant costs of any video system have been those of the

CODECs - traditionally expensivehardware devices capable of compressing a high-bandwidth analogue video signal into a lower-bandwidth digital form - and theNetwork Interfaces and Hardware. The high-cost of the latter being due to the fact that the computer networks used to carry digitalvideo data over large distances have needed to be of high-bandwidth (certainly >64Kbps and often as high as 2Mbps) and hence required specialist computer equipment.

However, in recent years the price of CODECs has fallen whilst their specifications have improved. For example, it is now possibleto purchase a hardware CODEC that can compress a video signal to less than the crucial 64Kbps figure for less than £2,000. The64Kbps barrier being important because it is the bandwidth available from a single ISDN 'B' channel - the dial-up data serviceoffered by many telecommunications service providers. Using ISDN rather than dedicated communication lines significantly reduces the running costs of a video conferencing system.

Additionally, there has been the development of software CODECs that are able to use the processor power of a desktop computer tocompress and decompress digital video streams. Whilst software CODECs cannot equal the performance of their hardwarecounterparts (working with lower image resolutions and fewer frames of video per second), they substantially reduce the cost of creating a video conferencing system.

The Architecture of the Macintosh

The system architecture of the Macintosh allows all the main components of a video conferencing system to be integrated in ahighly modular way. At the centre of this architecture is Apple's time-based data handler - QuickTime. The QuickTime extensionto the MacOS operating system is now installed as standard on all Macintoshes and, amongst other things, provides videocompression and decompression facilities in software (with the ability to integrate hardware 'accelerators' and CODECs) and allowsvideo digitising boards to easily integrate with the Macintosh environment through their own 'VDIG' extensions. Additionally, theMacintosh conforms to the ISO Seven-layer networking model, allowing applications to be shielded from the underlying computernetwork used. The relationship between the structure of a video conferencing system and the Macintosh architecture (and inparticular, QuickTime) is shown below in Figure 2.2. Clearly, this diagram is just intended to show the logical relationships between the various components involved.

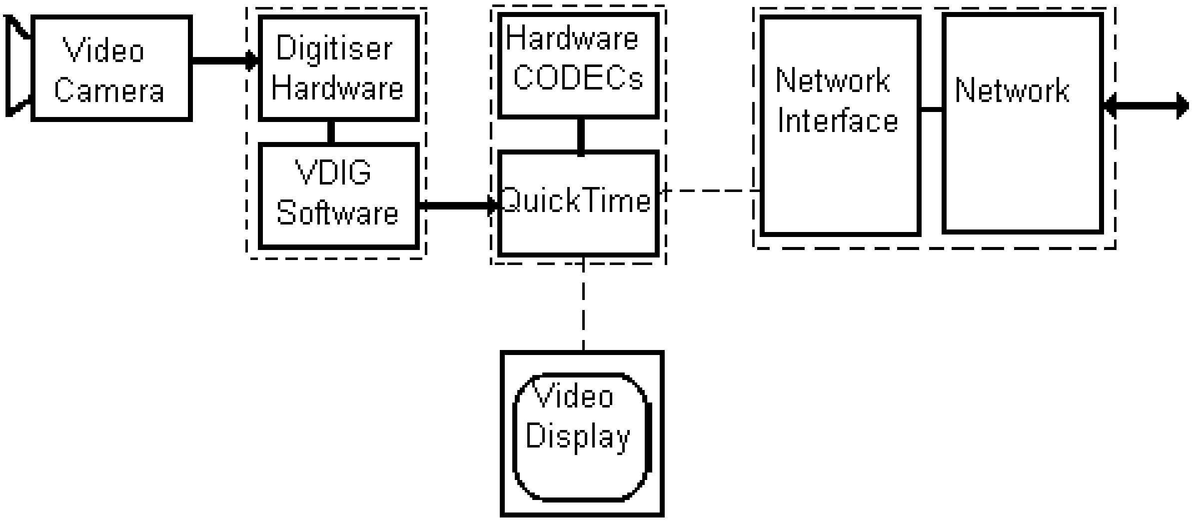


Figure 2.2. Video Conferencing on the Apple Macintosh

It is worth noting that having stated that QuickTime and the Macintosh's networking architecture provide and ideal frameworkwithin which a video conferencing system can function, some Macintosh video conferencing systems (in particular the older ones) donot necessarily work in this way - with their CODECs operating independently from QuickTime and the video conferencingapplication interfacing directly with the networking hardware (e.g. an ISDN adapter). However, this mode of operating is rare and is likely to become increasingly more so.

Video Conferencing Systems on the Apple Macintosh

A number of video conferencing packages are available for the Apple Macintosh platform. These are listed below in Figure 2.3. andcategorised in terms of the digitising board they use, whether or not the CODEC is hardware- or software-based, the type ofcomputer network used and the approximate price. Clearly, the video conferencing market is growing rapidly and this list will no doubt be incomplete. Similarly, prices are likely to change.

Perhaps the main point to notice is that the main price difference between systems is between those that use software CODECs(and give lower frame-rates) and those that compress and decompress the video signal in hardware. Additionally, most 'high-end'video conferencing systems use dedicated video digitisers (as opposed to using 'off-the-shelf' or the AV Macintosh built-in digitisers)and ISDN communications although an increasing number will perform over high-speed modem lines (albeit at a lower frame-rate).Similarly, there is a move to the support of IP networking - allowing video conferencing packages to run over Ethernet, Token Rings and even the Internet (at, of course, much lower frame-rates!).

	Digitiser	CODEC	Network	Price
VidiMac	**Cutsom***	**H/W***	**ISDN***	**£4495**
Visit	**Custom***	**H/W***	**ISDN***	**£3850**
IRIS	**Custom***	**H/W***	**ISDN**	**$5000**
Cameo	**Custom***	**H/W***	**ISDN**	**$1595**
Connect	**Custom***	**H/W***	**Modem** **IP** **ISDN**	**£3599**
ES-F2F	**Spigot** **AV Mac**	**S/W**	**Modem** **IP** **ISDN**	**£250**
CU See Me	**Spigot** **AV Mac**	**S/W**	**IP**	**free**

* = included in price given
Spigot = SuperMac VideoSpigot video digitiser
AV Mac = Macintosh built-in video digitiser
ISDN = Integrated Digital Services Network compatible
Modem = Runs over high-speed modem link
IP = Runs over IP-compliant networks

Figure 2.3. Video Conferencing products on the Apple Macintosh

Chapter 3

The University of Derby Video Conferencing System

As part of this project we established a six-node video conferencing network at the University of Derby based on the CUSeeMe videoconferencing package (developed at Cornell University) and Apple Macintosh computers. The great advantage of using CUSeeMe is,of course, cost - the CUSeeMe compression/decompression system is software-based and the software is available as freeware, so theonly expense needed to create a video conferencing workstation (in addition to that of the networked computer) is the cost of a video digitiser and video camera (see Appendix 1 for more information on how to obtain CUSeeMe).

CUSeeMe allows a suitably equipped computer (it can be a Mac or PC) to transmit a 16-greyscale video image via an IP networkconnection to another computer for point-to-point video conferencing, or to a video 'reflector' for multi-party conferencing (theCUSeeMe reflector allows up to to 8-way multi-party conferences). The transmitted frame-rate of the video image depends on thebandwidth of the intervening network, although a guide to its performance is that you can expect approximately 1-2 fps to betransmitted over a high-speed modem IP connection (PPP or SLIP) and between 10 and 20 fps over an unsaturated 10MbitEthernet link. As is discussed later, most of our video links took place over Ethane and microwave links - resulting in the transmission of moderately clear video images at about 5-7 fps.

There are a number of controls available when using CUSeeMe. The most important of these is the bandwidth control which putsan upper limit on the amount of network bandwidth used. It is recommended by the developers of CUSeeMe that this should not be set higher than 100Kbps. A CUSeeMe window and one of its control panel windows are shown in Figure 3.1.

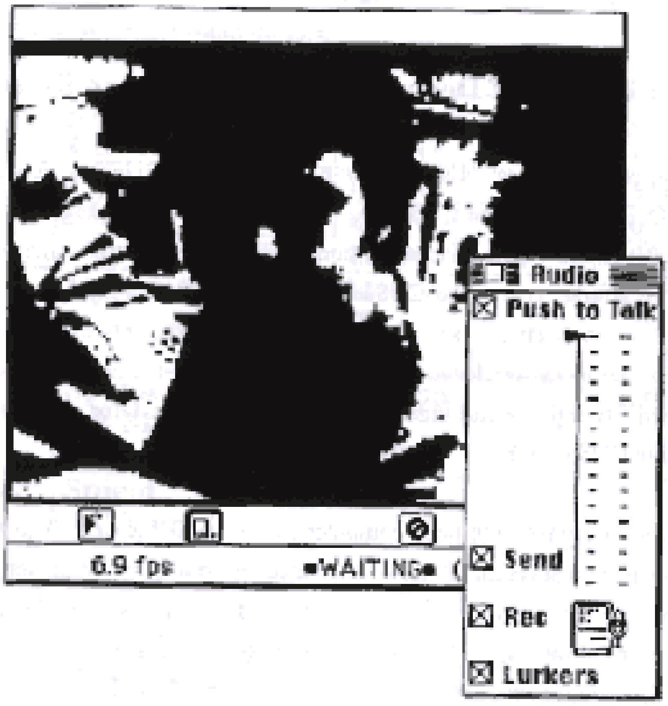


Figure 3.1 The CUSeeMe window

Rather than use the audio transmission system built into CUSeeMe (based on a software package called Maven) - which is bothbandwidth intensive and prone to loss of quality - all audio links used the University's standard telephone system. The University ofDerby telephone system allows up to 6-way conference calls, hence multi-way CUSeeMe video sessions with multi-way audio were possible. Where available headset telephones were used.

Of the six video conferencing nodes established, four were located in the Britannia Mill building at the University of Derby and twowere located in the Keddleston Road buildings approximately 1 mile away. Within each building the computers were connected via a10Mbit Ethernet and the two buildings were connected by a 4Mbps microwave link. Some video conferencing sessions were also established via the University's 64Kbps JANET connection.

The Video Conferencing Workstations

Each workstation consisted of an Apple Macintosh (various 'flavours') with 8Mb RAM, a SuperMac VideoSpigot video digitiser anda video camera. It was found that at least 8Mb RAM was required if CUSeeMe was to be used as a 'background' application - any lessthan 8Mb and the user would typically have to quit all existing programs in order to make a CUSeeMe link with a colleague. TheVideo Spigot device was purchased primarily because it was the only suitable piece of video digitising hardware available at the time.Some compatibility problems were encountered with it, primarily to do with the version of the VDIG and QuickTime software used, although once these were settled the Video Spigot functioned adequately.

A variety of video cameras were used. Including camcorders, security cameras and - purchased especially for the project - two 'Peach'micro-CCD cameras. These tiny greyscale cameras are sold for £110 as electrical 'components' and require external power supplied and video cables, but are still extremely good value for. They also performed well and came in narrow- and wide-angle versions.

The CUSeeMe Video Reflector

The CUSeeMe video reflector (also developed by Cornell University) is freely distributed as 'C' program source and runnable code forvarious computer platforms. For our experiments we ran the reflector under UNIX on a Sun SPARCstation IPX. At its simplest,the reflector does just as its name suggests - it 'reflects' any incoming video stream back to any users connected to it, to allowmulti-party video conferencing sessions. However, it is also possible to use the reflector to create video 'channels', some of which areprivate (restricted to certain IP numbers) and others of which are usable by anybody. The reflector can also be configured to display a 'Message of the Day' to anybody who connects to it.

The Layout of the Video Conferencing Network

The six video workstations and video reflector were oriented in the following configuration: one workstation in Sean Clark's office,one workstation in Prof. Scrivener's office, one workstation in the Research Office, one workstation in the CSCD Lab., oneworkstation in Computer Services (for a limited duration), one workstation for general use in the staff room and a secondworkstation in the CSCD Lab. (for a limited duration). The video reflector was running the SPARCstation located in the CSCD Lab. This layout is illustrated in Figure 3.2.

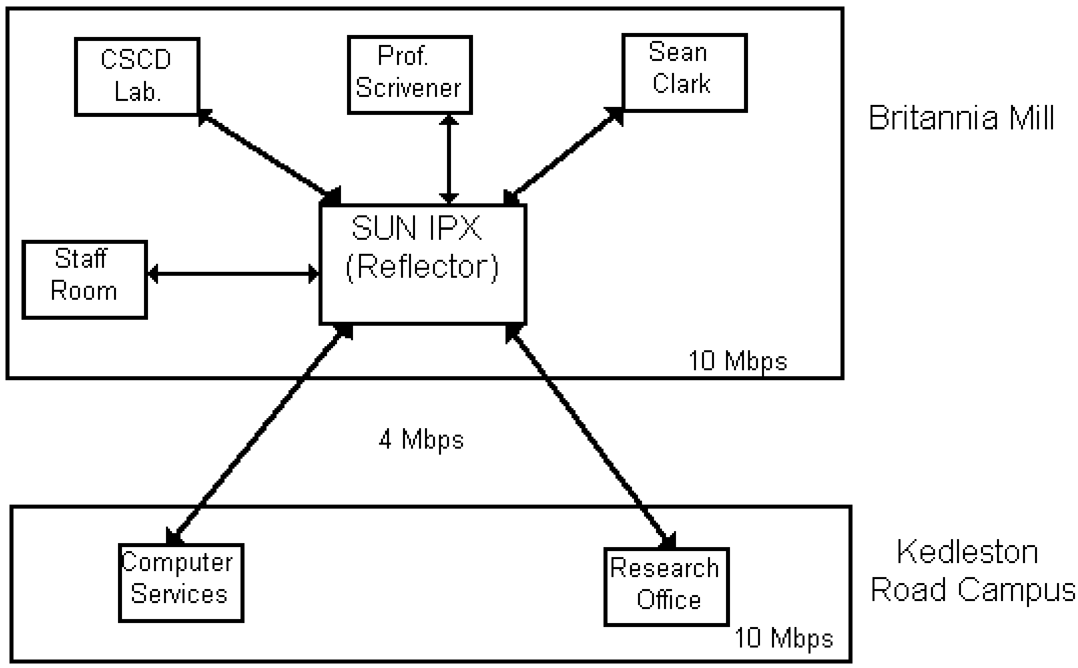


Figure 3.2. The layout of the video conferencing network.

Improving the Video Conferencing System

A number of more recent developments in Apple Macintosh technology have improved the cost-effectiveness and functionality ofCUSeeMe as a video conferencing tool even further. Firstly, many Macintoshes now come complete with AV (audio-visual)capabilities. An AV facility removes the need for a add-on Video Spigot card and a version of CUSeeMe is available for AV Macs. This would have removed the need to solve the Video Spigot 'VDIG' compatibility problem experienced.

Secondly, a purely digital video camera is now available for the Apple Macintosh. The Connectix QuickCam (available from mostMacintosh dealers) costs around £120 and is a greyscale camera that is able to deliver a video signal at approximately 15fps to theMacintosh's serial port. Since this device is purely digital, no video digitiser is needed. The frame rate and image quality is quitesufficient for CUSeeMe use and, again, a version of CUSeeMe is available that can use it.

Chapter 4

CUSeeMe User Questionnaire

The first study carried out in our series of investigations into the use of video conferencing was based around a questionnaire thatwas sent to members of the CUSeeMe e-mailing list. The purpose of this exercise was to gain an understanding of the way in which video conferencing packages such as CUSeeMe are currently being used in companies and Universities.

The complete questionnaire is given in Appendix 2. Questions were grouped into five main categories: 1) User Profile; 2) Usage Patterns; 3) Usability; 4) Network; and 5) General Comments.

Summary Of Responses

User Profile

We had 50 responses and of those 44 were male. 34% of respondents were Researchers, 14% were students and 40% employees ofcompanies. One was a Museum Curator. Nearly half of the respondents were from the United States and only three were from theUK. All but one respondent used the Internet and E-mail as a normal part of their day to day work. Most had heard aboutCUSeeMe from a colleague (30%) or in some way from the Internet (32%). 90% of respondents used CUSeeMe on the Apple Mac while two people used both Macs and PCs.

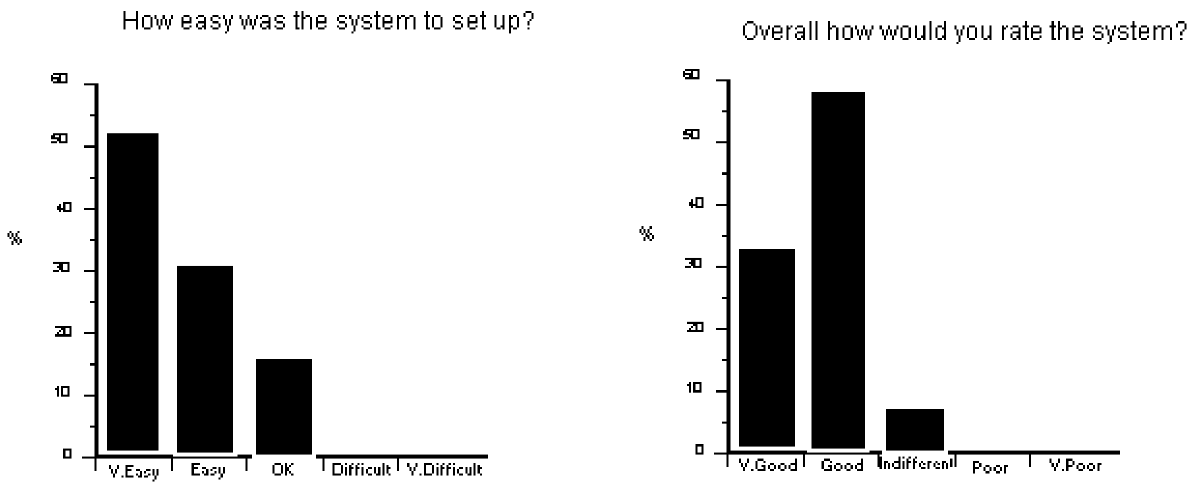
Usage Patterns

Usage patterns show three leaving the system on 24 hours a day. 19 respondents used it for about 1 hour a week. 15 respondentsused the system between 1 and 2 hours a day. 12 respondents used it for between 2 and 6 hours a week. Well over half therespondents did work in collaborative work groups, but of those only two regularly used the system to have face-to-face meetings,however 16 occasionally do. 12 respondents used CUSeeMe in conjunction with a telephone link. 29 use it in conjunction withMaven software or built other network-based in audio links. Three had used CUSeeMe in conjunction with a shared drawing surface and some expressed the desire to do so.

The uses of the system are varied from a security system to keeping contact with distant friends and relatives. More common wasthe use of CUSeeMe in helping to link students with tutors, small group meetings between different sites. The informal uses suchas keeping in contact was also very common mainly between dispersed colleagues, two respondents actually used it as a 'virtual corridor' with different colleagues. Some were evaluating the system as an alternative to face-to-face meetings.

Usability

Respondents were asked to rate how easy the system was to set up from Very Easy to Very Difficult , over 80% rated it Easy or Very Easy to set up (See Figure 4.1). Nearly 60% of respondents rated the system Good to use in overall terms, with 34% rating it Very Good (See Figure 4.2).



Figures 4.1. and 4.2.
How easy was the system to set up? Overall how would you rate the system?

Usability Problems

Usability problems can be summarised into three main areas of Sound, Hardware and Frame rates. There were a number ofcomments about the poor quality of sound provided by Maven [CUSeeMe s built in audio system]. Hardware problems ranged fromdigitiser incompatibility to some Macs not being able to run the system at all. The Frame rate was too slow for about 4 respondents.Various other comments were about bugs in the software causing the system to crash, as well as comments about the Internet not being able to support the frame rates and not being reliable enough!

Usability in Relation to Other Video Conferencing Systems

A total of 17 other video conferencing systems had been used by respondents and 13 of those were rated in the three areas of RefreshRate, Quality of Image and Ease of Use. CUSeeMe gained good ratings for Ease of and was only surpassed by the NV system onUNIX system. CUSeeMe did less well on the other two factors especially the Refresh Rate and Quality of Image. The best systemrated was Eclipse which had high ratings for Refresh Rate, Quality of Image and for Ease of Use. The next most mentioned system after CUSeeMe was NV and then PictureTel.

Network

Most respondents (28) used a LAN with >64K Internet connection. 13 respondents used a High Speed Modem InternetConnection. The impact of CUSeeMe on the LAN differed between those who did not feel "it was an issue" and those who felt itdid "put a strain on it". 6 respondents felt that as more people used the system that the impact would become significant on the LAN.

Using CUSeeMe was not seen to be a problem by 6 respondents in terms of affecting the Internet. Again fears were expressed that as more people use the system the impact on their Internet would increase.

General Comments

Respondents were asked to leave any general comments about video conferencing and ways in which they use it. A selection of the responses are given below:

> "CU-SeeMe offers video conferencing on low-cost platform. It offers the possibility of ubiquitous use and resultant innovation among large communities of users who might not otherwise have access to this technology e.g. K-12 teachers/students in classrooms. "
>
> "Internet conferencing systems with simple interfaces and inexpensive hw/sw is the answer to making conferencing an everyday part of life. "
>
> "Room sized systems, ISDN requirements, dedicated links and dedicated TI service is not the answer. "
>
> "All should incorporate audio and shared whiteboard interface within one s/w package."
>
> "Currently I'm just setting up a group of interested users on campus. I am also currently involved in a proposal for setting up a physician's WAN and see CU-SeeMe as a possible tool."

"Mutual awareness - we run cu all the time in conjunction with two other labs and anyone else who joins the reflector."

"Regular demos to visitors also watching project videos/remote lab demos networking experiments. "

"Definitely the way I like to work."

"If the developers can continue to refine the interface so that it is easy to use (and I think they will), CUSeeMe has the potential to be a significant technical innovation. Something like CUSeeMe is likely to be the telephone of the next century"

"Excellent use of the Internet; Additional work should be done to best enable this over the 14.4 or 28.8 kbps modem connections that a rapidly growing set of Internet users will be using."

"I use it as a virtual office with several colleagues across the country who have jobs similar to mine."

"Distant NYSERNet Executive Committee members will soon be connected so that, with the aid of a conference phone call, the need for costly face to face meetings off site will be largely avoided. Board members can meet without having to leave their offices."

"NYSERNet would very much like to test CUSeeMe to deliver training and helpdesk services. A user could start up CUSeeMe and see if anyone was physically seated at the NYSERNet support desk. If so, the person could either send email or phone call the helpdesk person. "

"Possibly this could be made part of a MUD/MOO, adding a visual element to what has been textual so far. Imagine a virtual library MOO with the ability to see the librarian sitting at the reference desk."

Conclusions

It can be seen from the replies to the questionnaire that most people felt that CUSeeMe was a easy to use video conferencing tool.The uses to which it is put are varied ranging from surveillance, viewing lab demonstrations to electronic meetings and discussionsand it is perhaps this which is the main finding from the study: there is more to video conferencing than simply attempting toreplicate face-to-face meetings. Given a flexible video conferencing tool, even one that only offers a low frame rate and lowresolution video image, people will find a wide variety of genuinely useful applications for it.

Chapter 5

The Laboratory Study

For our second study into the use of video conferencing systems we used the University of Derby Video Conferencing system to runa series of artificial video conferences. The conferences involved placing small groups of users at different workstations and asking them to use the video conferencing system, a shared drawing tool and a telephone audio link to work together on various tasks.

After each collaborative session the subjects were asked to complete a questionnaire in which they were asked to score various aspectsof the collaborate environment. Questions were on a five point scale from Agree Strongly to Disagree Strongly . The questionnaireas designed with both positive and negative statements and contained questions relating to the following the categories 1) TheAppropriateness of the Task; 2) Social Communication; 3) Performance of the System; 4) Audio; and 5) Group Working (the full questionnaire is given in Appendix 3).

Artificial Tasks

In developing the artificial tasks for the study we aimed to identify areas either had close similarities to the types of activitiescommon in day-to-day work or would offer particular insights into the usability of the video conferencing system. Five such tasks were developed and one pair of collaborators completed each task:

> Task 1 - Jointly Produce a Document, and Task 4 - Agree the Allocation of Access Funds. Two people were placed at differentvideo conferencing workstations and asked to use a CUSeeMe link and a telephone link to work together on the task which waspresented to them in the form of a written brief. For Task 1 the brief simply contained a number of document elements (text,pictures, headings etc.) and the two collaborators has to agree upon a layout. For Task 4 the brief consisted of a scenario in whichthey collaborators had to agree on the allocation of limited funds to a number of project proposals. No other collaboration tools were used.
>
> Task 2 - Design of an Office Layout, was a Design task that involved asking a pair of collaborators to use a telephone link, a CUSeeMe link and a shared drawing tool called Aspects to work together on the design of an office layout (see Appendix 4).

Task 3 - University Scholarship Committee, each collaborator was given a different student and had to argue that their studentshould receive a University Scholarship. There we told that they had to come to an agreement by the end of the session so a degree of explaining and negotiation was involved. Only a telephone link and CUSeeMe link were used.

Task 5 - Charades, this task simply involved playing a game of Charades via the video conferencing link. Each collaborator was givena list of TV programmes and films to act out for the other. Clearly, the goal of this task was to see how successful CUSeeMe was at supporting gestural communication. Only CUSeeMe was available with no audio link (see Appendix 5).

The Experimental Procedure

The subjects were sat at their video conferencing workstations and told that they had up to one hour to work on the brief. At theend of the session they were both given a questionnaire. All tasks were completed over the 10Mbps Local Area Network, giving a video frame-rate of approximately 7-10 frames per second.

Results of the Questionnaire

The following results are divided into the categories of the questionnaire that were identified earlier. A total of nine responses werereceived (one questionnaire was not returned) to the questionnaires and although small a few key findings can be drawn from their responses.

The Appropriateness of the Task

100% Agreed or Agreed Strongly that the discussions held over the system went well. All but one respondent Agreed or AgreedStrongly that it was possible to fully express what they wanted over the system. 70% disagreed that it was hard to judge when tospeak and when to wait. Of those it applied to, 2/3rds Disagreed that it was difficult to write as well as stay involved in the discussion.

Social Communication

Nearly 45% Disagreed that it was difficult to initiate eye contact whereas nearly 45% Agreed or Agreed Strongly that it wasdifficult. Just over 60% Disagreed that it was easy to maintain eye contact. 55% Disagreed or Disagreed Strongly that gestures bythe other participants were unclear, whereas only 33% Agreed Gestures were unclear. All respondents Agreed or Agreed

Strongly that the system did enable the group to build a rapport with one another.

Performance of the System

2/3rds Agreed that the update rate of the screen was sufficient for the discussions held. Nearly 90% Agreed or Agreed Strongly thatthe quality of the image in terms of resolution was adequate for the uses made of the system. Nearly 90% Disagreed or DisagreedStrongly that the display adversely affected the exchange of information between participants. Less conclusive was the issue of theposition of the cameras, 45% disagreed with the statement that "the position of the cameras were not acceptable for the discussions we held. 33% did however Agree that the camera position was not acceptable, 11% actually Agreed Strongly.

Audio

Over 75% Agreed or Agreed Strongly that it was easy to identify who was speaking. This finding is not particularly startling becauseall the interaction only had only two participants! 1/3rd neither Agreed nor Disagreed that the discussion we held were only possible using the system set up rather than a normal phone call. 1/3rd did however Agree and 11% Agreed Strongly.

Group Working

2/3rds Agreed that it was clear what all the participants thought about the discussion at different times. Of those it applied to nearly90% Agreed or Agreed Strongly that it was easy to reach a conclusion to their discussions. Over half Disagreed or Disagreed Strongly that the system set-up was not well suited to the type of tasks we did, whereas only 1/3rd Agreed.

Discussion and Breakdown According to Task

This study showed how video conferencing suited some tasks more than others. It became clear, for instance, that the Task 2(Design an Office Layout) did not really need the video link, with the link and shared drawing surface providing sufficient means for collaboration to take place.

The Charades Task highlighted how powerful a video link can be in terms of communication. No audio link was provided andparticipants could only type their answers to each other. One the whole all items were guessed quickly. Although clearly, larger videowindows would have made the process easier and a greater bandwidth allowance would have given a smoother image and allowed a clearer expression to occur. Once again the subjects reported that the position of the cameras was critical to success.

The discussion of who should gain what amount of money from an Access Fund committee (Task 4.), resulted in some usefulfindings. A few practical problems were reported. For one collaborator their video camera was to the side and the other partner feltthat a head on display would have been preferred rather than the profile they received. Since the paper brief became the focus forboth participants, rather than a shared view on screen, it was felt that an on-screen text document with the video window of theother participant next to it would have mirrored a true head to head discussion far more easily and naturally. One of the participantsdid feel the video enabled a sense of rapport to be developed and hence it became easier to know how to react to the other user and judge his sense of humour or the level of discussion.

Chapter 6

The Real World Study

Our third investigation consisted of a detailed study of the use of the University of Derby Video Conferencing System by a realworkgroup. The focus of the study was the University of Derby s Research Office and, in particular, the University's Director ofResearch, (who will be referred to in this section as 'S'), and the Administrative Manager for Research, ('C'). As Director ofResearch, S has a cross-institutional role but is also Director of the Design Research Centre, located in the Britannia Mill buildingof the School of Art and Design: S's and his secretary's offices are located at the Mill. As Director of Research S is responsible forthe operations of the Research Office, managed on a day to day basis by C. The Research Office is located at the Kedleston Roadcampus, separated from the Mill by a distance of approximately 1 - 1.5 miles: twenty minutes on foot and around five minutes by car.

Research policy and procedure is an area of major development at the University and consequently S and C need to keep each otherappraised of their actions on a more or less daily basis. S and C co-ordinate their day by day activities by phone and email. S isfrequently at the Kedleston Road site for meetings, some involving C, which provide opportunities for C and S to meet on an adhoc basis. However, S and C schedule a regular weekly update and planning meeting. This may take place either at Britannia Mill or Kedleston Road depending on convenience.

S and C used the video conferencing system for around six weeks as they thought appropriate. They were not asked to use the videoconferencing system or to give it particular preference, but they did understand the nature of the project and agreed to participate:hence were under some obligation to use the system. In the event they held around ten meeting using the system and S used the system once with W, his secretary, who happened to be in the Research Office at Kedleston Road.

At the end of the trial period both S and C took part together in a semi-structured interview, using the Usability Questionnaire(Appendix 3) as the framework. We took this to be the most appropriate way of gathering the data as we were interested in theiroverall view of the system having used it for a number of purposes over an extended period. Typically, S and C used the meetings toupdate each other and to agree and plan the work ahead. All the meetings involved reference to text documents held at each end ofthe link. Generally speaking, S and C would agree the subject and the requirements (e.g. the documents to be referenced) of themeeting beforehand by telephone or email. In the following Sections we summarise the results.

Response to the Questionnaire

The Partner Images

S and C found that they could not obtain, and therefore sustain eye to eye contact. This was almost certainly due to the fact thatS's camera position gave C a three-quarters portrait view of S. Nevertheless, both S and C thought the position of the camerasacceptable for the discussion. Similarly, although both S and C were conscious of the jerkiness of the image due to the frame rate, both regarded the screen update and image quality as sufficient for the tasks undertaken.

Co-ordination and Communication

S and C used the internal telephone system for the audio channel and found the voice quality audible and clear. Given the imagequality and frame rate, S and C found that image and sound were not synchronised, so the video did not provide direct cues to turntaking. Nevertheless, both felt that is was easier to judge when to speak and when to wait with the video than when using audio alone.

In all but one case S and C were the only participants in the meeting and hence S and C had no difficulty in identifying who wasspeaking. For one meeting there were two participants at the Kedleston Road end of the link, C and Y , an external auditor whoagreed to de-brief S on the results of an audit of the procedures for managing research income. S reported that he had no difficulty judging who was speaking during this meeting but felt that audio (or voice recognition) was the primary cue.

Both S and C felt that they were able to express what they wanted using the system, that gestures were clear, and that whatparticipants thought of the discussion at different times was clear. Neither did S or C felt that the display adversely affected the exchange of information between them and were able to stay involved in the discussion when engaged in other tasks, such as writing.

However S indicated that the fact that S and C knew each other so well may have contributed to this positive assessment. Forexample, S felt less comfortable with the system when interacting with W, who at the time of the study had only recently joined theCentre. He explained this by suggesting that visual loss due to frame rate and image quality may be easier to tolerate in situationswhere the participants are familiar with each other because this familiarity makes it easier for them to interpret residual cues.Hence, S found it less comfortable working with Y because of the impoverishments in the expressive and gestural potential of the medium arising from the low frame rate and image quality.

Finally, although the display did not adversely affect the exchange of information, there were occasions when it was not sufficient forexchanging information at all. For example, there were a number of instances where S and C wanted to show the other printed material via the video, but in general the video quality was not adequate for this purpose.

The Discussion and the Task

Both S and C felt that the discussions held over the system went well, that successful conclusions were reached and that the systemwas suitable for the tasks for which it was used. Yet neither felt that the discussions would have been impossible by telephone.However, both agreed that they would not have bothered to try and hold the meetings over the telephone, preferring to meetface-to-face. Furthermore, both were strongly of the opinion that the addition of video augmented the telephone, i.e. made it possible to engage in activities that would otherwise be very difficult using only the telephone.

Other Comments

In answering the questions S and C provided further insights into the benefits and limitations of video conferencing systems. S andC suggested that the addition of video allowed them to deal with interrupt, intervention and pause events that would have been discomforting over an audio channel.

On one occasion, for example, C asked during the course of a meeting if she could leave (interrupt) it for five minutes to attend toan urgent matter elsewhere in the building. S agreed to this and found the video supportive for a number of reasons. First, S wasable to watch C leave the room, which provided a signal that allowed him to break from the task in hand to work on another duringthe absence of C. During this absence background activities, such as other parties entering the Research Office, confirmed that thechannel was still open. When C returned, S saw her enter the Research Office and arrange her material ready to continue themeeting, which in turn allowed S to disengage from the task in hand. Thus the video made it possible for the meeting to be fluentlyand effectively interrupted and recommenced in a manner not that dissimilar to face to face meeting and a distinct improvement on audio only.

The effects of interventions are also ameliorated by video. On one occasion C received an unannounced visit from an ex-colleague(V). Arriving unannounced V caused a slightly frantic haptic exchange which at first confused S. However, at least S could see thatsomething was happening and S quickly realised that C had a visitor. The arrival of V caused C's attention to be completely divertedfrom S; at no time did C formally break off the exchange with S or explain to S what was happening. However, C did explain to Vthat she was engaged in a video conference meeting which S clearly overheard. The intervention was short-lived and C and Sresumed their meeting with ease following V's departure. Both S and C were of the opinion that this event would have been extremely difficult to manage with audio alone.

During the course of a meeting S and C frequently referred to documents or took down notes. Inevitably, therefore, they were notattending to each other all the time, and there were often pauses in the conversation. However, S and C found that they were ableto gauge, via the video, what the other was doing and hence had little difficulty in dealing with what were often long pauses. S and Csuggested that the ability to "see" what the other was doing was a crucial factor in dealing with the pauses in conversation arisingfrom shifts in attention and focus of activity. Again S and C felt that these pauses would have led to uncertainty, anxiety, and confusion during a phone call.

S and C described one particular event where the video was useful, and which generally suggest need for multiple channels. Duringone meeting C accidentally and unconsciously disconnected the telephone line, but didn't detect the event because she was attendingto a document. S tried to gain her attention via the video without initial success. CUSeeMe allows a message line to be typed whichappears to the bottom of the video window. S typed a message indicating that the line was down and eventually managed to draw C'sattention to it. C re-dialled the number and the session continued uninterrupted. Here video was used to get C's attention but the normally redundant text channel provided the means for explaining the problem.

Discussion

Overall both S and C were very positive about the video conferencing system. Although not a substitute for face-to-facemeetings, both S and C were of the opinion that the system could be used on a day to day basis as an alternative to some face to facemeetings. Most interestingly, both S and C were convinced that audio and telephone was a much more flexible option thantelephone alone, enabling interactions and work activities to be realised that would be difficult, if not impossible, using only the telephone.

Generally. the medium was adequate for the task although there were occasions when the resolution of the video was notsufficient for the exchange of some material (i.e. type). Clearly, there are likely to be other domains, such as design, where such limitations might prove not merely a nuisance but unacceptable.

Furthermore, with respect to general communication and co-ordination, S and C's experience tends to suggest the subjects overall response to the system may depend on the rapport that already exists between participants. For example, S and C'sresponses suggest that the good rapport between them and their familiarity with each others' style of communication and workingallowed them to overcome the inadequacies of the technology. It may be that strangers working together to achieve a real goal viathe system might be less tolerant of its deficiencies and therefore generally less positive about its value as a work support.

Chapter 7

Discussion

After having conducted such a varied range of investigations into video conferencing a number of lessons have been learnt. Perhpasthe most important is that the successof a video conferencing depends not just upong its technical specification,but the nature of the tasks it is intended to support and personalities of the users.

We feel that certain tasks, such as those in which the collaborators focus on some sort of worksurface (such as a shared drawingsurface) seem to have less of a need for video in addition to audio. That is, an audio link such as a telephone and a collaboration toolmay well be sufficient to complete the task in hand. However, tasks which require more in the way of social communication -perhaps first-time meetings, or less structured collaborations - can benefit from video conferencing - even at low frame-rates. This became evident from the 'real world' study conducted between members fo the Research Office.

We have further evidence of this. In a more recent study we linked design students in Holland with art students in Derby. The distributed teams were given the task of designingand 'installation' artwork for later construction in Derby. The collaborative systemwe constructed included the ability for the students to 'meet' via CUSeeMe - which was running over the Internet at a rate of about2 frames per second. In our analyssis of this project (which included other groups without such elaborate collaboaration tools) thefact that the students (who had never met before) could see each other was flagged as being very important and a major factor inbuilding a working relationship between them. Hence, here we have an example of low-frame-rate video conferencing having a real benefit.

The Apple Macintosh was found to be a highly suitable platform for video conferencing. As is discussed in this report, the architecture of the computer system suitss this style of application and a range of video conferencing tools are available - of which CUSeeMe is only one example (but the least expensive and therfore more accessible). The development of the Macintosh as a videoconferencing platform looksset to continue with an announcement by Apple that a video conferencing extension (based around QuickTime) will soon be available for MacOS. Giving a more seamless integration of different video conferencing tools on the Macand hopefully providing additional software-based CODECs capable of compressing and decompressing video images to even lower bandwidths without the need for expensive CODEC hardware.

Finally, it is worth noting that some quite 'pratical' issues can significantly affect the perceived success of a video conferencingsystem. For example, the position of the video camera is important. As is the ease at which the video conferencing application canbe accessed by the user

- if they have to close all the applications they are running on their computer in order to use it they will beless encouraged to do so. Additionally, users need to be able to develop their own usage patterns. At times they may only wish toconfer via, say, a telephone link but at other times they may wish to use the video conferencing systems as well. In summary, givingthe users control over the use of the video conferencing application and the position of the cameras etc. is a significant step towards getting the system accepted and used.

Chapter 8

Conclusion

In conclusino,we found this project interesting and enlightening. At the Design Research Centre we are now firm advocates of the benefits of vidoe conferencing as a tool to support day-to-day work as well as our less frequent international collaborative projects.

We also plan to use the Internet-accessiblilty of CUSeeMe to extend our electronic art gallery. The DRC Virtual Gallery (at URL http://dougal.derby.ac.uk/gallery) currently contains work by a number of Derby-based artists and has a discussion system for use by people interested in electronic arts. One of the next stages in this project is to use our CUSeeMe 'relfector' to enable artists to 'broadcast' video images of their work. By using the GAllery's Web pages to 'book' a transmission timethey will be able to reserve a time to show their work to other interested parties. It will be interesting to see if this project is successful and if the video bandwidth available via a CUSeeMe link can support 'creative' activities.

Appendix 1

The CUSeeMe System

This is an extract of the "Read Me file from the current version of CUSeeMe used by the University of Derby Videoconferencing System.

====
CU-SeeMe README file
1-16-95
by Dick Cogger

CU-SeeMe0.80b1 - BETA VERSION for (self-selected) Testers only

Software Versions

CU-SeeMePPc0.0.80b1 and CU-SeeMe68k0.87b1 are now available. Both of these are major functional enhancements beyond the previous 0.70 series. Obtain by FTP to cu-seeme.cornell.ed/pub/video

RELECTOR There is also a new version of the reflector, 2.50b2, which is needed to use some of the new features of 0.80. It is on the usual anonymous ftp site,
cu-seeme.cornell.edu/pub/video/reflector.

About This Document

This document is a (somewhat crudely) consolidated document for version 0.80. See the latest CU-SeeMe.CHANGES..txt for an extensive revision and release history. Briefly:

0.70 versions added audio support.

0.80 versions added:
1) A "SlideWindow" facility with which you can capture 640x440 stills, transmit to all participients (who have SlideWindow open) and then point with the mouse and have everyone see the pointer. You can also switch among a number of slides and have the remote particpants see the same thing. SlideWindow is an "AuxData Application" which is invoked with the SlideWindow menu item on the Conference menu.

2)An "Auxilliary Data Transport" providing reliable one-to-many delivery of data constitutin auzilliary materials for sharing in a conference.

Data is transmitted as "Items", with an item being defined as a string of bytes contained in memory. The AuxData transport takes care of packeting and any neccessary retrys to ensure reliable delivery. This transport is used by the built-in SlideWindow application or by plug-in AuxData applications (see below).

3) A Plug-In interface so that separate modules can add functionality to CU-SeeMe. There is a "Software Developer's Kit" for Plug-In's, consisting of documentation and sample plugins and two CodeWarrior projects with libraries to facilitate development. If one or more plug-ins is in the same folder as CU-SeeMe at launchtime, a menu will be added (for each).

4)A "talk" plug-in (in source, also, as an example) for sharing typed messages as with IRC. The Talk module implements a "chat" window that allows exchange of text messages.

5)An AuxData tracing tool for examining data flows when debugging or testing AuxData applications. The AD-Trace module is a testing or debuggin tool that shows all "AuxData" traffic.

6) Also there is a new version of the reflector which will allow sending of AuxData and also prevent sending of AuxDatta to participants who are not running the appropriate AuxData application (or who don't have it). Version 0.80 will not attempt to send AuxData if connected to a version of the reflector earlier than 3.00b1. Version 3.00b2 has a few bug fixes and is currently running at Cornell at the usual address, 132.236.91.204. You can use this reflector or you can make point-point connections to test the AuxData applications provided with the beta 0.80. If any reflector operator can run the new reflector, currently 2.50b2, please do and advise this list. This new reflector also had additional facilities for interoperating with vat and nv.

Basic CUSeeMe Information

Cu-SeeMe, a desktop videoconferencing program, for Macintosh and PC, is available free from Cornell University under copyright of Cornell and its collaborators. Cu-SeeMe provides a one-to-one conference, or by use of a reflector, a one-to-many, a several-to-several, or a several-to-many conference depending on user needs and hardware capabilities. It displays 4-bit grayscale video windows at 160x120 pixels or at double that diameter, and now includes audio on the Mac. So far as we know, CU-SeeMe was the first software available for the Macintosh to support real-time multi-party videoconferencing on the Internet.

Cu-SeeMe is intended to provide useful conferencing at minimal cost. Receiving requires only a Mac with a screen capable of displaying 16 grays and a connection to the Internet. Sending requires the same plus a camera and digitizer (see specs below) which can cost as little as $100 to add on.

At this time CU-SeeMe runs on the Macintosh (with audio) and the PC (without audio) using an IP netowrk connection. With Cu-SeeMe each participant can decide to be a sender, a receiver, or both. WARNING: Although being improved with each version, CU-SeeMe is not mature production software - USE AT YOUR OWN RISK. And also, PLEASE TREAT THE INTERNET KINDLY - keep b/w limits set down under 100kbps, or less if you share limited bandwidth with others. Many, many folks connected to the Internet can use CU_SeeMe with default settings and cause no problem to anyone else; but unfortunately, not everyone. If you don't know whether using CU-SeeMe will mess up the network for someone else, CHECK IT OUT
first, please.

Cu-SeeMe was initially written for the Macintosh by Tim Dorcey with design assistance and sponsorship by Richard Cogger of the Advanced Technology group in the Network Resources division of Cornell University's Information Technology department (CIT). Important early contributions cam from: Cornell University Meiccal Colleges (CUMC), Scott Brim, and John Lynn.

Since Oct. 1, 1993, the CU-SeeMe Project receives funding from the National Science Foundation. A very significant collaborative effort at Cornell University Medical Colleges (CUMC) is contributing substantial expertise and code.

Development contributers to Macintosh CU-SeeMe0.80: Cornell: Richard Cogger (Project Director/PI), Time Dorcey, Scott Brim (Co-PI), John Lynn, Larry Chace; CUMC: Steve Erde, Aaron Freimark, Aaron Giles, Erik Dahl; UIUC: Charley Kline (audio).

This material is partially based on work sponsored by the National Science foundation under Cooperative Agreement No NCR-9318337. The Government has certain rights in this material.

What do you need to use CU-SeeMe?

Specifications to RECEIVE video:
- Macintosh platform with a 68020 processor or higher
- System 7 or higher operating system (it "may" run on system 6.0.7 and above)
- Ability to display 16-level-grayscale (e.g. any color Mac)

- an IP network connection
- MacTCP
- Current CU-SeeMe application
- Apple's QuickTime, to receive slides with SlideWindow

Specification to SEND video:
- The specification to receive video mentioned above
- Quicktime installed
- A video digitizer (with vdig software) and Camera;

Supported as of 0.70b13:

 - ONE OF-
  Video Spigot hardware (street price approx. $380.)
  AV-Mac (vdig built into system)
  CopmuterEyes/RT SCIS port digitizer
       - PLUS -
       camera with NTSC lvpp output
      (like a camcorder) and RCA cable.
 - OR_
  Connectix QuickCam serial prot digitizer (with camera)

*****NOTICE: NO OTHER DIGITIZERS WILL WORK UNTIL FURTHER NOTICE****

To obtain CU-SeeMe

Use ftp (File Transfer Protocol) to:

Server: cu-seeme.cornell.edu
UserID: anonymous
Password:
directory: /pub/video

Download the latest README file, if there is one later than the date at the top of this file you are reading. Then get the application and other files you need.

CU-SeeMe Maillist

For anyone interested in following developments in CU-SeeMe or its use, an automated maillist has been established. The list is provided for unrestricted discussion of the CU-SeeMe packet video software under development by the Cornell Cu-SeeMe project and its collaborators. Developers and project management all read the list. Currently there are over 1000 members on the list, and there are usually several messages each day. We, and other users, would also like to hear about and discuss innovative uses of CU-SeeMe. Pleae write and tell us your story. To join the list, send a message with the following line as the entire message body to listserv@cornell.edu:

subscribe cu-seeme-l

(Substitute your actual name, please; it's amazing how many don't.) You should receive a confirming message with extensive instructions on use of the list.
====

Appendix 2

CUSeeMe User Questionnaire

The following questionnaire was sent to the members of the CUSeeMe electronic mailing list. People were asked to complete as many answers as possible and to return the form by email. Approximately 50 replies were received.

Questionnaire

Please place an "*" in the box given or type you answer.

1 User profile

Are you:

Male	[ ]	A researcher	[ ]
Female	[ ]	A student	[ ]
		An employee of a company	[ ]
		Other	.....

Do you use email to communicate as part of your day-to-day work?
Yes [ ]
No [ ]

Do you use networks such as the Internet as part of your day-to-day work?
Yes [ ]
No [ ]

Where did you hear about CUSeeMe?

Which version of CUSeeMe do you use?
Mac [ ]
PC [ ]
Version Number ...

2. Usage Patterns

On average, how many hours do you use the CUSeeMe system?
Per Day [ ]
Per Week [ ]

Do you work in collaborative work groups?
Yes [ ]
No [ ]

If so, do you use CUSeeMe in place of face-to-face meetings?
Occasionally [ ]
Regularly [ ]
Never [ ]

Do you typically use CUSeeMe in conjunction with a telephone link?
Yes [ ]
No [ ]

Do you typically use CUSeeMe in conjunction with another type of audio link, usch as Maven?
Yes [ ]
No [ ]

Do you typically use CUSeeMe in conjunction with other groupware systems such as a shared drawing surface?
Yes [ ]
No [ ]

Can you breifly summarise the uses to which you place CUSeeMe?

3. Usability

How easily was the system set up?

[ ]	[ ]	[ ]	[ ]	[ ]
V.Easy	Easy	OK	Difficult	V.Difficult

Overall how would you rate the system?..

[ ]	[ ]	[ ]	[ ]	[ ]
V.Good	Good	Indifferent	Poor	V.Poor

What problems have you had with the system?

What other Video Conferencing products have you used?

How would you rate them out of 1- in terms fo the following attributes?

	Refresh Rate	Quality of Image	Ease of use
CUSeeMe	[5]	[5]	[5]
......	[ ]	[ ]	[ ]
......	[ ]	[ ]	[ ]
......	[ ]	[ ]	[ ]
......	[ ]	[ ]	[ ]
......	[ ]	[ ]	[ ]

4. Network

What network do you use?

Local Area Network only	[ ]
High Spped Modem Internet Connection	[ ]
LAN with 64K Internet Connection	[ ]
LAN with >64K Internet Connection	[ ]
Don't Know	[ ]

What impact do you thing your usage of CUSEeMe has on you Local Area Network (only answer if appropriate)?

What impact do you think your usage of CUSeeMe has on you Internet connection (only answer if appropriate)?

5. Other General Comments

Do you have any other comments on video conferencing systems?

6. Finally

Would you like your name to be placed on our project e-mailing list?

Yes [ ]

No [ ]

Would you like a copy of the project final report?

Yes [ ]

No [ ]

Would you mind us sending you another questionnaire in the future?

Yes [ ]

No [ ]

Appendix 3

Usability Questionnaire

The following questionnaire was given to each subject after the 'artifical' studies. A similar questionnaire was also used after the 'real
world' study. Questions 1 to 18 were answered using the following scale:

Disagree Strongly	Disagree	Neither agree Nor Disagree	Agree	Agree Strongly

1.The discussions held over the system went well.
2.It was difficult to initiate eye contact.
3.The update rate of the screen was sufficient for the discussion we held.
4.It was easy to identify who was speaking.
5.The system set up was not well suited to the type of tasks we did.
6.It was possible to fully express what I wanted over the system.
7.Gestures by the other participants were unclear.
8.The quality of the image in terms of resolution was adequate for the
9.uses we made of the system.
10.The vocies of the participants were not clear
11.It was easy to reach conlcusion to our discussions
12.It was hard to judge when to speak and when to wait
13.It was easy to maintain eye contact
14.The display adversely affected the exahnage of information between participants.
15.The dicsussion we held were only possible using the system set up
16.rather than a normal phonecall.
17.It was clear what all the participants thought about the discussion at different times
18.It was difficult to write as well as stay involved in the dicussions using the system
19.The system enabled the group to build a rapport with one another.
20.The position of the cameras was not acceptable for the dicussions we held.

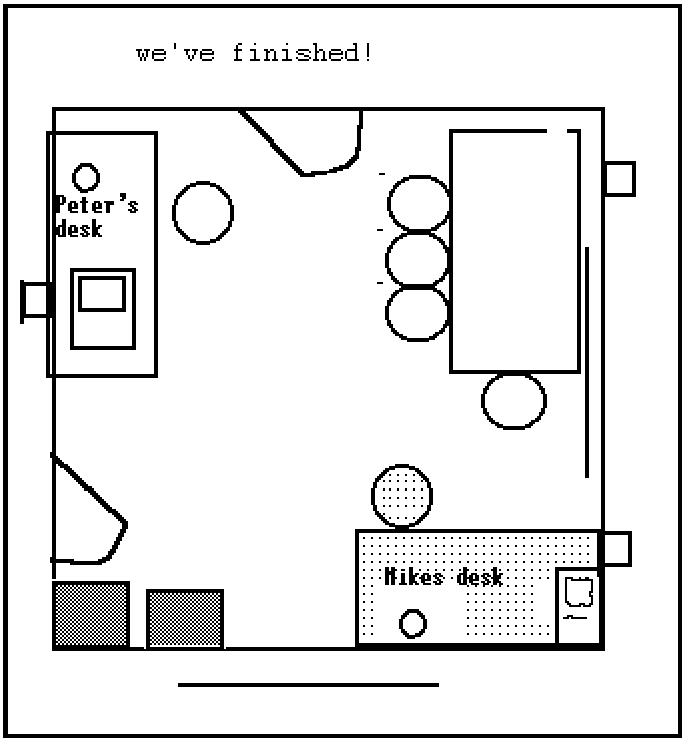
21.Do you have any other comments about the videoconferencing system.
22. What type of tasks did you use the system for

Thank you for taking the time to fill in this questionnaire

Appendix 4

The Office Design Task

The Office Design Task was supported with a shared drawing package called "Aspects" as well as CUSeeMe. Aspects allows two or more pople to share a drawing window via their computers. The image below shows the typical output from an Aspects shared drawing session:



Appendix 5

The Charades Task

Charades

Take it in turns to act out one of the programmes/films on the list given you, each of you has a list of 9 programmes/films each. Try to complete the list in the 20 minutes but don't worry if you fail, there is no order. You can only use the keypad to communicate. The aim is to get as many between you as possible. Good Luck.

List 1

- Psycho II
- Top Gear
- Peak Practise
- Rocky
- Cheers
- Hart to Hart
- Question Time
- Red Dwarf

List 2

- Jaws 3D
- Dr Who
- Thunderbirds
- Muppets
- Bottom
- Crossroads
- Terminator
- Superman
- Baywatch