Videoconferencing in Home Environments

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Abstract

This paper discusses videoconferencing and how it could be applied in home environments. The paper will not concentrate on specific details about how to actually install a videoconferencing system to home environment but merely tries to give an overview about the current and also about the future solutions. The paper tries to point out requirements for home networks and their key problems. There are currently many different kinds of applications already available and the reader is familiarized with the most interesting existing applications. The paper also tries to provide a vision of what kind applications could be offered to customers when equipment needed for holding videoconferences become cheaper and more common. The reader is also shortly introduced to the most commonly used videoconferencing standards and protocols.

1 Introduction

A videoconference is a live connection between two or more people which reside in different locations. The purpose of holding a videoconference is that the people participating can communicate with each other using audio, text and video even if the reside across the globe. At the simplest form a videoconference can be held with two people transmitting text and static images between two different locations. On the other hand videoconferencing can provide transmission of full-motion video images and high-quality audio between multiple participants and locations. [1]

Currently videoconferences are mostly used by organizations and they have not yet made a breakthrough in homes of consumers although there are plenty of ways consumers can benefit from them. By using videoconferences both organizations and consumers can save time and money. The most of the savings are made because people don't have to travel from place to place. Videoconferencing can also sometimes make it possible to hold meetings that could not otherwise be arranged. For example because of the busy timetables and inability to travel to a meeting to a different location. People who are physically disabled can also benefit from videoconferencing. They can for example telecommute from their homes and attend virtually to meetings which are actually held in the office.

There are obviously requirements for having a successful videoconference. The most important requirement is that the voice of speaker can not be discontinuous. It is still possible to follow a videoconference meeting even if the video stream cuts off, but audio breaking

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is simply unbearable. Of course then the videoconference depreciates to a regular phone without visual capabilities. More about the requirements of videoconference sessions and also demands for network environment are discussed in chapter 3.

Videoconferencing can be used for many different purposes. The most typical usage is a a business conference but there are also plenty of other applications for videoconferencing. Videoconferencing can also be efficiently used in home environments to provide services for regular consumers. Applications of videoconferencing and services suitable for home environments are discussed in chapter 5.

2 Videoconferencing Protocols

The International Telecommunication Union (ITU) has developed many different standards for videoconferencing. This paper will present shortly H.320, H.323 and H.324 protocol standards. These ITU protocol standards belong to so called “umbrella” standards which means that they have specified a set of supported protocols for video, audio and control (see Figure 1) transmission and compression. The Internet Engineering Task Force (IETF) has developed Session Initiation Protocol which is according to it’s definition used to tie telecom and Internet together. This chapter will deal with only the most common solutions. There are also other standards available but they are not discussed in this paper.

2.1 H.320

H.320 is a protocol standard which defines how videoconferences can be held using ISDN lines. Figure 2 represents a situation where two H.320 terminals are communicating using H.320 through ISDN network. ISDN lines provide 64 kilobyte (56 in some countries) per second transfer rate but it is possible to use multiple ISDN lines to achieve better transfer rates. H.320 can be used both to multipoint and point-to-point sessions. The umbrella standard specifies the protocols standards for audio, video and control. H.320 contains three classes which define minimal requirements for systems to be within certain class. [13]

- Class 1. Contains only the minimum requirements to be H.320 compatible. The system has to support e.g. 7.5 frames per second and also Quarter Common Intermediate Format resolution (that is 176x144). It also has requirements for audio and video protocol support.
- Class 2. Contains the minimum requirements and also as many additional features as the manufacturer wants to support.
- Class 3. Supports all the minimum requirements and also all the additional requirements.

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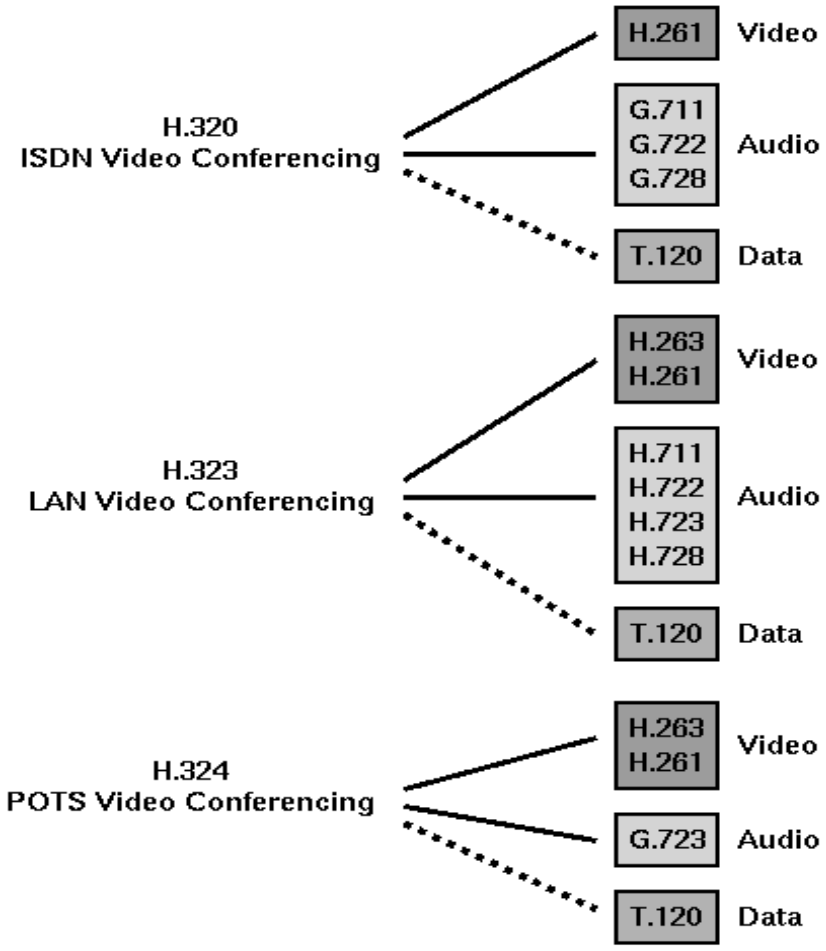

Figure 1: ITU Standards for Videoconferencing [11]

2.2 H.323

H.323 is a standard developed by the International Telecommunication Union for transmitting real-time audio, video and communications over packet-based networks (for example TCP/IP). H.323 sets standards for components, protocols and procedures providing multimedia communications over Local Area Networks (LAN). Figure 3 shows high level picture of two H.323 terminals communicating through a packet switched network. H.323 is capable of handling multiple terminals communicating with others using multimedia. H.323 standard has three versions, the first was published in October 1996. Problem with the first version was that did not cover all the requirements needed by Voice Over IP applications. These requirements came up after the publishing of the first version. The second version was published in January 1998 and it added the needed features. The third version was introduced on September 1999 but it added only minor improvements to previous versions. Interoperability between H.323 and other standards and protocols is handled by using gateways. Gateways used for connecting different networks are out of scope of this paper. [8][7]

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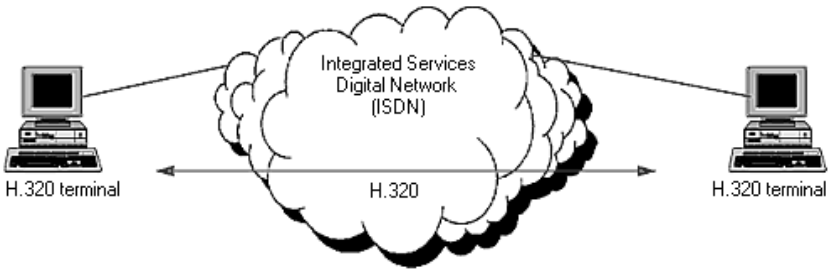

Figure 2: H.320 terminals in ISDN network. (Outlook of of the picture from [7])

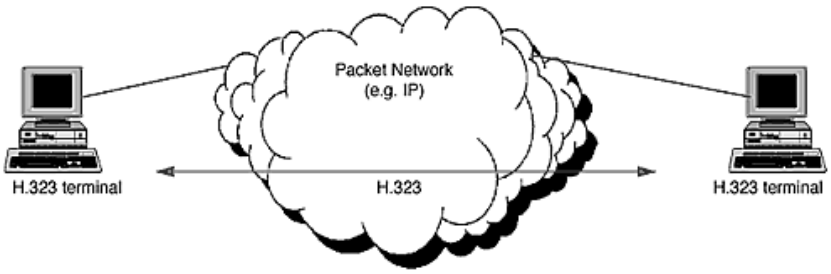

Figure 3: H.323 Terminals in a Packet Network [7]

2.3 H.324

H.324 is a standard for sharing voice, video and data over Public Switched Telephone Network (PSTN). Figure 4 represents a situation where two H.324 terminals are connected through PSTN. H.324 uses single analog phone line for transmitting the data. This standard was developed after the H.320 and H.323 standards when the high speed modems (28800 bps) were introduced. Because the transfer rate is so low, the H.324 standard states that video phone products can deliver 4 to 12 frames per second. Also the size of the window where the video is shown is limited by the transfer rate. The maximum size of the window is about 176x132 pixels for a fluent communication. However H.324 standard makes it possible to consumers at home to use videophoning because they can use the basic phone line instead of ISDN lines and LAN solutions. This is not actually so big achievement because of the frame rate and the resolution of the video are so low. In the future the H.324 protocol will vanish completely. One reason for this is that faster Internet connections are becoming more common and cheaper. [6]

2.4 Session Initiation Protocol

The Session Initiation Protocol, developed by the Internet Engineering Task Force and defined in RFC 2543, is an application-layer control protocol. As an application layer protocol it resides on top of the protocol stack in both OSI reference model and in TCP/IP reference model. It is used for creating, modifying and terminating sessions with one or more participants. SIP can be used both in unicast and in multicast sessions. So it

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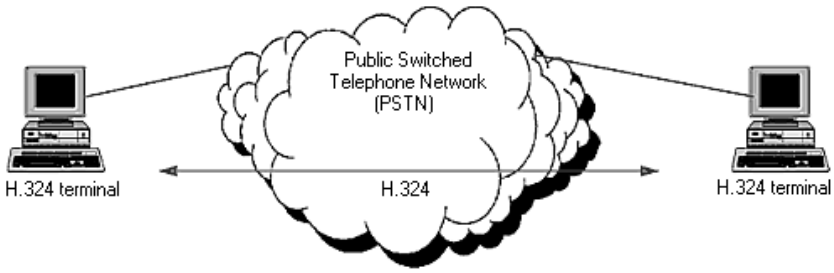

Figure 4: H.324 Terminals in a PSTN. (Outlook of the picture from [7])

is possible to use SIP to Internet telephony calls including multimedia and also to hold videoconferences. SIP is designed to be independent of the lower level protocols. [5]

SIP supports the following features relating to establishing and terminating multimedia communications:[5]

- User location. The feature is used to determine the end system to be used for communication.
- User capabilities. The feature is used to determine what kind of capabilities participating parties have and to negotiate about the parameters.
- User availability. The feature is used to determine if the called party is willing to start the communication.
- Call setup. The feature handles negotiation of parameters between called and calling party.
- Call handling. The feature handles transmission of the data and termination of the call.

3 Videoconference Requirements

3.1 General videoconferencing requirements

Videoconferencing itself does not set too high requirements for home environments. The basic requirements are:

- a phone line, ISDN line or a faster connection to the Internet (for example adsl or a cable modem)
- applications to start and control the conference
- a camera to shoot the conference
- a microphone for speech and other audio

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The basic requirements listed apply with personal computers. It is also possible to use a dedicated videoconference unit, which are usually TV based. The problem with TV based solutions is that they are more expensive than the PC based solutions and specially in home environments money plays an important role. On the other hand TV based units are extremely easy to set up and use.

For home environments so called desktop conferences are usually good enough solutions. Desktop conferencing means that the participating parties are shown on PC's desktop using some specific application. This is a cost saving solution because then the user does not have to have a "videoconferencing room" where the user would have video projectors to project the picture to the wall, multiple video cameras and microphones to transmit the conference to the other party.

Most important requirement when a videoconference is held is to transmit audio signal and the quality of it. Without audio it is impossible to follow the conference unless the other part is doing a pantomime. If the picture or the video is missing it is not usually as fatal as audio, because then the conference depreciates to a regular phone call where participants can still follow the discussion. Of course the video stream is also very important. Otherwise all the equipment are useless and participants could use normal phones to communicate. [2]

The audio and video stream require synchronization so that the voice of the speaker is synchronized with the speaker's lips. This is called lip synch. Without lip synch the audio signal would come sooner (usually) than the video picture and following the conference would be annoying. The lip synch is specially important for music applications.

Also delays set requirements for the Internet connection. Delays of 100 milliseconds are noticeable but tolerable. Delays greater than 250 milliseconds are annoying. Over 450 millisecond delays are simply unacceptable.[2] The ideal situation of videoconferencing is that people would feel that they are in the same room with the rest of the participants. This is attained if people can put the technology to the background and just concentrate to the communication itself. [1]

Interoperability of different videoconferencing protocols is possible using for example specific gateways. For example it is possible to have a videoconference session with parties which are using H.320 and H.323. It is even possible to include parties with different speeds to the same session. These issues are however out of scope of this paper.

3.2 Videoconferencing Network Requirements

Although it is possible to hold videoconferences from home environments using the plain old telephone network the quality of video is too poor to even consider this as an option. ISDN lines are also a common solution for Internet connection in home environments. Usually homes have only one ISDN line or two at most. However a good quality videoconference needs multiple ISDN lines so one line based solution are not the answer for videoconferencing to spread to homes. Having multiple ISDN lines open at the same time is expensive. To achieve TV quality the user needs 6 ISDN lines, that is 384 kbps. IDSN lines have their strong points because an end-to-end connection can be made between the participating parties. So the communication will be made using the reliable telephone net-

work and the data is transmitted using telephone lines instead of the Internet. The telephone network is always harder to wire tap than the Internet. For home environments security is not as crucial requirement than it is for business purposes. Of course people might have business videoconferences from home also and then security plays an important role.

The digitized audio and video require large amount of data. Compression methods for both are needed. Videoconferencing systems typically use some sort of lossy compression for both audio and video. The codecs used for compression depends on the network bandwidth constraint. The network itself sets some requirements for compression. If the network is very slow higher level of compression has to used. This leads to lower quality of the video. With unreliable networks it can be simply impossible to hold videoconferences if the connection keeps breaking all the time. [1]

3.3 Optional Security Features

When a business videoconference is held over a untrustworthy network encryption methods are needed to guarantee that the security of sent data is not compromised to unwanted parties. This can simply be done by encrypting the sent traffic. The encryption has to be done in every end and by all the participants of the videoconference. The receiving parties have naturally to able to decrypt the data in order to understand it. This encryption can be done by using a public key methods or using symmetric encryption. A typical home user rarely needs encryption methods.

If the home user wants to protect the ports used by the videoconference application he needs to set up a firewall. Home users can also have a firewall provided by a third party e.g. by Internet operator or by their company. One has to remember that if the home user has previously had a connection to the Internet the need for a firewall has already existed. Then the only thing to do is to configure the firewall to understand the videoconferencing applications. For example a firewall that does packet filtering is a good choice for SIP and H.323 because they both use the packet switched networks. Packet filtering firewalls can for example be configured to filter packets based on source address, destination address and based on the protocol used. So it is easy to add to the rules of the firewall which source addresses and protocols are permitted to access the videoconferencing server. If the videoconference equipment includes a router, the routing device itself can also act as a firewall filtering out unwanted connections. [3]

Proxy server is a firewall whose purpose is based on the user information check whether or not the user's client is permitted to perform the action. The proxy server is the only machine actually connected to the outside network. All the traffic from the outside or to outside network goes through the proxy server. If the home user uses H.320 for videoconferencing and calls an ISDN call using a PPP line for example to company's number it can be lot harder to poke a hole to the proxy server to accept videoconference packets. If the organization makes a hole to the proxy server it affects the whole internal network because all the traffic goes through the proxy server. Usually the user has to at least apply a hole to the proxy server from the authorities of the organization. [3]

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4 Problems with Videoconferencing

One of the problems with videoconferencing is that consumer's have too high expectations. They expect TV-quality video which level at least in home environments can not usually be reached. The current problem with home environments is that most of the homes don't have a Internet connection at all or the transfer rate is insufficient for videoconferencing. The H.324 protocol standard offers a way for consumers at home to have sessions by using a analog phone line and a fast modem. In reality this is no option because the quality of the video is low and can only be viewed with a low resolution.

Using the H.320 protocol standard on the other hand requires that the consumer has a ISDN line at home. Having only one line does not offer much higher quality than using a modem. To be able to perform smooth good-quality videoconference session at least 4 ISDN lines are required. So in order to make videoconferences more common to homes of the consumer's should the consumers not only get the equipment needed for conferencing but also to update their Internet connection to a level capable of approximately 256-384 kbps. The fact that videoconferences have not become common actually slows down the spreading to home environments. It is no use to have fancy videoconferencing equipment and a fast Internet connection if there are no service providers or friends who you can contact. [2]

Audio configuration requires some skill from the user. Echoing can be a big and annoying problem if the system is not setup right. The microphones must be set at the right distance of the speaker and the volumes on all the end points have to set at right level in order to avoid echoing. [12]

Addressing is a bit of a problem with videoconferencing. Different protocols support different kind of addressing methods. For example H.323 has four different address types: by DNS name, by IP address, by a phone number and by H.323 specific ID (which looks like a email address). Session Initiation Protocol on the other hand supports only DNS addresses. The addresses are like email addresses with the following format: *SIP:user@company.com*. A SIP server contains a mapping between a DNS address and the IP address. The SIP server can be a proxy server or a redirect server. The former means that when the SIP server receives a request for a connection to be opened it uses it's own algorithms to determine the user's location. The latter of the two means that the redirect server returns the IP address (transformed from the DNS address) back to the client who will then make the connection to the other party. Another problem is that home user's usually have dynamic IP addresses, that are for example acquired from the DHCP at operation system start-up. So H.323 idea to use IP addresses directly is good a idea only for a static IP addresses. [14] [4] [9]

5 Videoconference Applications

In this section typical applications of videoconferencing are discussed. Applications are divided to four categories: telecommuting, telemedicing, distance learning and amusement usage. One has to remember that videoconferencing can basicly be used whenever two or more people need to communicate with each other. So the applications presented in this

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paper are just examples of possible usage. In the future there could be a whole new set of different services available.

5.1 Telecommuting

People tend to think that working at home is just doing some paper work and having a connection to the resources of the organization through Internet. But telecommuting can nowadays include a possibility to have virtual face to face meetings with colleagues and even to participate to more formal meetings by using a videoconference session. This can also mean more solutions to entrepreneurs and consultants to sell their services and assistance from the home environment. People can save both money and time when they are able to hold meetings with out leaving the home, the office or even the country. [1]

Videoconferences are nowadays also used for job interviewing. It is at least a good way to narrow down applicants for the job. This way videoconferences can save both the interviewer's and applicant's money and time.

5.2 Telemedicing

Usually telemedicing is used between doctors to have a second opinion from an expert. Doctors can also consult colleagues about operations and surgeries they are going to perform by using telemedicing. They can transmit for example x-ray images and discuss virtually face-to-face what kind of treatment should the patient have. This calls for very high-quality video and may need specialized videoconferencing equipment. This also sets requirements for network connection and careful planning and implementation is needed to achieve it. [1]

Telemedicing can also be used in home environments. There are illnesses that do not necessarily need a physical appointment reserved from a doctor. At least a doctor can do a preliminary examination of the symptoms of the patient and decide is a regular appointment needed. Doctor could also do regular checks using videoconferencing and the patient does not have to leave the house. If the patient needs a real physical appointment then he can go to the clinic or the doctor can make a house call. Doctors can also identify whether or not a drug recipe needs to be renewed by contacting the patient by telemedicine.

One problem with telemedicing is legal matters. How can the patient get best possible care and to where can the patient complain if he has received bad care? The issue is even more complicated if the patient uses a virtual doctor appointment from another country. One solution is that people should only use familiar doctors who they can trust. Telemedicing can be considered as a service and the same rules could be applied to it as to other international trading through Internet. Medicine culture and treatment differs greatly for example in western and eastern countries. The patient is also partly responsible and should know what he is doing.

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5.3 Distance Learning

Different schools and educational purposes can obviously benefit by using videoconferences. The school can give private teaching to students and the students can remain at home. This could be one solution for disabled people who are unable to travel to schools to participate to regular classes and lectures. There could for example be a virtual class for students that are staying home and they would linked to the teacher and to each other by videoconferencing. Distance learning can be the key to open markets for videoconferencing equipment for home environments.

At the University of Oklahoma School of Music videoconferences are used to teach music to students. Primarily videoconferencing is used to bring guest lecturers virtually to classes to teach students. Videoconferencing is also used by the university staff to hold lectures around the country so that the teaching staff can remain at Oklahoma. Another application is to give private teaching for students which can remain home and neither the student or the teachers have to travel for example to a piano lesson. To teach and perform music requires high-quality audio and also high-quality full-motion video. An important thing is that the audio and the video are synchronized. For example if someone is singing lip synch needs to be almost perfect or otherwise the music experience is ruined. [12]

5.4 Amusement Usage

Videoconferences can also be used for amusement purposes. For example a parent could use videoconferencing to communicate with the rest of the family as a some kind of visual telephone. Or a child studying abroad can stay in touch with the parents by videophoning. As the equipment needed for holding the conferences become more common and cheaper there will be service providers which offer different kind of services for customers. One example of possible service could be improved chats where textual messages will be replaced by audio and video or even even some videoconferencing based date finding service.

6 Conclusion

So far there has not been a killer application for videoconferencing. The organization who first comes up with a killer application designed for home environments could make a lot of money. After the breakthrough application videoconferencing could quickly spread to the homes of consumers. There definetly is market for videoconferencing equipments, software and Internet connection in consumer markets also. There are plenty of applications and services for consumers which they could benefit from.

In this paper we have shortly introduced the most common videoconference protocol standards. We have also covered requirements for home environments. These requirements include general videoconferencing requirements as well as requirements for network. The problems of videoconferencing were gathered to it's own section which mainly discussed addressing and network problems. Finally a few possible applications have been presented to give an overview of different solution available and what kind of services there could be in the future.

One way to make videoconferencing more common to homes would be that employers would pay for the equipment and fill also the other videoconferencing requirements. That would raise telecommuting to a different level. Multimedia Messaging Service (MMS) will bring multimedia to mobile phones. For example Nokia will release their MMS capable clients during the second quarter of year 2002. The phones are equipped with digital camera that the user can take pictures and send them to friends. When the bandwidth of mobile telecommunication increases it will be possible to send live video stream with a device equipped with a video camera. Then at the latest videoconferencing will spread to the homes of consumers.

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