User Needs Assessment for Negotiating the Quality of Service
for Streaming Video Applications

by

Adina Manoli B.A. (Hon)

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Abstract

Eight focus groups were conducted to understand the user needs, problems and preferences when using and controlling streaming media applications over the Internet. During the focus-group discussion, participants received different types of information on quality of service (QoS) issues. This information was either a visual demonstration, with video clips of different video compression and frame rates, or a verbal description of QoS issues. Two user interface examples for controlling QoS, one simple and one complex, were also presented during the discussion. There was a significant main effect of user attitudes towards QoS and a significant difference in ratings for five different video attributes. Participants thought it was important to control QoS and they are willing to control it, but they are not nearly as willing to pay to have better QoS. These ratings were generally true for different aspects of quality, except that color was rated lower than frame rate, audio/video synchronization, resolution and image size. Participants' comments during the focus-group discussions that support the quantitative data are reported. Recommendations for including the capability to control QoS and for the QoS user interface are presented. The impact of video quality examples and user interface examples, as part of focus-group methodological issues, are presented as well.

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User Needs Assessment for Negotiating the Quality of Service for Streaming Video Applications

The increase of bandwidth and streaming technologies has made video on the Web viable. However, users still face many problems. Streaming video services are still extremely delay sensitive and network congestion can lead to poor video quality and end-user frustration. While attempting to deliver an optimal level of continuous media and network performance, the notion of Quality of Service (QoS) on demand has emerged. One way to ensure that users get the QoS that they want for multimedia materials over the Internet is to provide a user interface with control over the QoS on a dynamic basis at the desktop. A viewer can request and pay for higher, more consistent bandwidth as it is required to facilitate better quality audio and video. The first purpose of this thesis was to conduct a user needs assessment to understand user needs, problems and preferences when using and controlling streaming media. The second purpose was to investigate methodological and procedural issues in the use of focus groups to understand those user needs, problems and preferences. Before considering the use of focus groups, there is an introduction to the Internet, multimedia, streaming media and QoS.

Internet and Networks

The Internet is a medium that has fundamentally changed business processes and the way organizations and individuals exchange information. It is used for business purposes to sell, place orders, receive orders, collaborate, train employees, provide customer services and bid for products over the Internet. Consumers are using the Internet to exchange electronic mail, pay bills, conduct online stock transactions, calculate income tax returns, make travel reservation, shop and conduct research. They

also spend time on the Internet playing games, listening to music and viewing entertainment. In September 2002, there were approximately 606 million Internet users (“How many on-line?”, 2002).

The Internet is a global network connecting millions of computers (Dodd, 2002). There are many types of computer networks including: local-area networks (LANs), where the computers are geographically close to each other, usually in the same building; wide-area networks (WANs), where the computers are further apart; metropolitan-area networks (MANs), a data network designed for a town or a city; and the Internet that reaches around the globe. The networks communicate with each other over a suite of standardized protocols, Transmit Control Protocol/Internet Protocol (TCP/IP), in which data is broken up into “pieces of data” called packets.

The data sent from computer to computer may be analog information, such as speech, which is converted to digital or digital information directly stored on a computer such as programs, text or graphics in binary form. Packet switching refers to protocols in which messages are divided into packets before they are sent. Each packet is then transmitted individually and can even follow different routes to its destination depending on traffic on a particular route. Once all the packets forming a message arrive at the destination, they are recombined into the original message (“Webopedia”, 2003).

Internet traffic is sent at gigabit/sec. speed along the backbone, the main network connections, of the Internet. The Internet carries traffic on high-capacity, high-speed lines, often fiber optics, between on and off ramps. Carriers are companies that offer telephone and data communications between points in a country or between countries. The different carriers that operate Internets exchange traffic with each other at

metropolitan area exchanges and network access points (NAPs). The portion of the public network from the central office, which is often a telephone company, to the end user's location is the access network, sometimes called the "last mile" and sometimes called the "first mile." The last mile is represented by bulk cables, often fiber, from a central office into a neighborhood using digital transmission, while cables that go into individual homes often use analog signals over copper wire. Analog telephone lines measure capacity in hertz, which is the frequency of the channel in cycles/sec, while digital channels measure bandwidth in bits per second. Bandwidth is a measure of network transmission speed (Dodd, 2002). For example, a telephone conversation requires low bandwidth measured in a few kilobits per sec, while fiber optic backbones have broadband or high bandwidth measured in Megabits or Gigabits per second. Bandwidth represents the data that can be transmitted in a fixed amount of time, bits per second (bps) for digital signals and Hertz (Hz) for analog signals ("Webopedia", 2003).

Internet Service Providers (ISPs) aggregate traffic from many users and send it over the Internet backbone. Individuals and organizations connect their locations to the Internet through an Internet Service Provider via many types of telecommunication services including T-1, T-3, analog lines, digital subscriber line (DSL), integrated services digital network (ISDN) and cable TV facilities. T-1 is a dedicated telephone-line connection, known also as a leased line, for businesses connecting to the Internet and for Internet Service Providers connecting to the Internet backbone. A leased line is a line that is always connected as opposed to a dial-up connection. A T-1 connection supports data rates of 1.544 Mb/s and consists of 24 individual channels, each of which supports 64 Kb/s and can be configured to carry voice and data traffic. The Internet backbone itself

often consists of T-3 connections or faster. T-3 connections support data rates of about 43 Mbps and consists of 673 individual channels, each of which supports 64 Kb/s. T-3 lines are used for access to long distance companies, Internet access and high-speed private lines between company sites. Ca*net 4 which provides a national fiber optic backbone network across Canada is capable of carrying up to 300 Gbps.

The digital subscriber line (DSL) technologies, including the two main categories, ADSL and SDSL are used primarily for connections from a telephone switching station to a home or office, not between switching stations (“Webopedia”, 2003). DSL operates over the copper cabling already installed by the regional and independent telephone companies. It is an “always on” service in which modems don’t dial a telephone number to reach the Internet (Dodd, 2002). The last mile can also be covered by cable modems that operate on the hybrid fiber coaxial (HFC) cable infrastructure already in place for cable television. A cable modem converts digital data appropriate for computer use and storage into packets to send over cable TV lines. Because the coaxial cable used by cable TV provides much greater bandwidth than telephone lines, a cable modem can be used to achieve over 1 Mb/s access to the World Wide Web. Cable modems share bandwidth with other cable subscribers while DSL does not (“Webopedia”, 2003).

Many users accessing the Web or their corporate intranet encounter problems connecting to the desired site or find that the data moves slowly or irregularly. This problem arises because most data packets need to go through several routers, which are devices that connect several LANs, before they reach the final destination. Each time a packet is forwarded to the next router, a “hop” occurs. The more hops, the longer it takes for data to go from source to destination. Figure 1 illustrates a trace route for a typical

connection. Each row from the table is a hop between Internet hosts. Also the table shows the loss and the performance of each portion of that route. Note particularly, in the third column from the right, that the times and variability in times between hops is in msec. In the Internet, the number of hops, the time to make a hop and the variability in time are determined primarily by traffic. Although delays and variability caused by hops are not problems for computer data, they are extremely problematic for audio and video streaming of multimedia that require good timing and synchronization of packets.

Figure 1: Trace route example from Ottawa to www.eurescom.de

Introduction to Multimedia and Streaming

The World Wide Web is a vehicle for multimedia presentation of information in the form of audio, video, images, animations and text (Dodd, 2002). The World Wide Web, a protocol-based standard for transmissions over the Internet, links users from one network to another when they click on a link. The World Wide Web was developed in 1989 to make the information on the Internet more accessible. To navigate and access the World Wide Web, a browser is typically employed (Dodd, 2002).

Multimedia represents the use of computers to present text, graphics, video, animation and sound in an integrated way (Dodd, 2002). Multimedia applications were, until the middle of the '90s, uncommon due to expensive hardware and low bandwidth availability. With the increase of performance and the decrease in processing time, multimedia over networks is now common. Nearly all PCs are capable of displaying video. As media continues to migrate toward "everything digital", video too is becoming digital. Digital video (and accompanying audio) has the advantage of not degrading when copies are made, and, because it can reside on a computer disk, it is easy to store and retrieve. It can be edited and easily integrated with other media, as well as compressed and transmitted with no or little loss in perceived quality.

Users listen and watch broadcasts from all over the world at home or at their office. The type of audience can be broken into three groups: narrowband, midband and broadband. Narrowband can be defined as an end user (receiver) with access to the bandwidth only up to approximately 56 kb/s. While narrowband users represent the most Internet users today, a rich broadcast media experience is hard to achieve in this environment. Midband users are those who have access that range from 128 kb/s to 256

kb/s. This is a growing population of end users, especially home users, who are able to achieve this bandwidth through cable modems and DSL. Broadband usually refers to speeds above 1 Mbps (Dodd, 2002).

Until recently video, which requires high bandwidth, has been delivered by a “download and play” method. In this approach, the entire video file is downloaded over a network to the client and stored on the hard drive for subsequent viewing. With lower bandwidth connections it is usually better to download the video and view it off of the hard drive. The advantage of this approach is that high quality video can be delivered, even over a low bandwidth network. The disadvantage is that the user may have to wait for a long time for the download to complete and have a large amount of disk storage space available to store the video file.

With video streaming, files can be played as they are downloaded to the client, thus eliminating the necessity to completely download the file before playing. With any streaming technology, a web user does not have to wait to download a large file before seeing the video and hearing the sound. Instead, the media is sent in a continuous stream and, after a short buffer period, is played as it arrives. The user needs a player, which is a special program that decompresses and sends video data to the display and sends audio data to speakers. A player can be either an integral part of a browser or a separate special purpose program. Streaming has the advantages of playing sooner, not occupying as much disk space, minimizing copyright concerns because the data is not permanently saved, and reducing the bandwidth requirements for video (“Video Streaming Technology”, 1998).

Video containing a lot of action requires a frame rate of 15 frames per second at a steady rate to look good (“Surmont Design”, 1998). This is impossible without a very high-speed connection with few hops and interruptions from other network traffic.

A video stream is usually sent from pre-recorded video files, but can be distributed as part of a live broadcast. Broadcasting means that a message or presentation from one person or device is forwarded to multiple destinations. Unicasting refers to transmitting separate video streams to each computer requesting data. Even though multiple users might request the same data from the same server at the same time, duplicate data streams are transmitted, one to each user. In contrast to unicast, multicasting conserves network bandwidth by sending a single stream of data to a collection point or tunnel (“Networking Encyclopedia”, 2003). For example, a concert in Toronto might be carried to a location in Ottawa on a single line. Then a number of computers in Ottawa would connect to the concert in Ottawa instead of all connecting to Toronto. Thus, broadcasting is a general term while multicasting refers to transmitting a single message that a select group of recipients can simultaneously receive, whereas unicasting refers to sending the same message directly to each recipient.

Video streaming takes advantage of advances in video scaling and compression techniques but also the use of network protocols that have been developed for real-time media streaming (“Video Streaming Technology”, 1998). A potential problem with video streaming is that the packetized video is buffered at the client, and then the video begins to play out of the buffer as the file streams in. There are problems with the packet switched communication networks for real-time data transmissions. The delay or loss of frames, audio clarity, lip synchronization during the speech, and a general perturbation of

the relationship between the visual and auditory components has a tremendous effect on the “watchability” of the multimedia content (Apteker et al., 1995). Real-time applications, such as compressed voice and some types of interactive video are assumed to be able to tolerate small variations in the rate of transmission and small losses of cells. The delay is also inherent due to the transmission and hops associated with routing. Non-real-time applications are bursty, not constant in nature. More delay and variation on speed is tolerated with non-audio/visual data but the loss of cells is better tolerated with audio/video data than with text and graphic data (Dodd, 2002). To maintain the real time characteristics of video and audio, packets can be “dropped”, but that would never be acceptable with text and graphic files.

Quality of Service

One of the main concerns with multimedia over the Internet is Quality of Service. Quality of Service was defined as the set of quantitative and qualitative characteristics of a network that are necessary to achieve a level of functionality and end-user satisfaction with an application (Bochmann, 1998). The term QoS originally emerged in communications to describe characteristics of data transmission. Quality of Service is concerned with technical characteristics such as the rate of information transfer, the latency and the probability of the communication being disrupted (Open Distributed Processing, ISO/IEC, 1995), or is described as being mainly related to speed and reliability of transmission, such as throughput, delay, jitter, bit error rate, cell loss rate, and connection establishment failure probability (OSI, 1995). Delay or latency represents the amount of time it takes a packet to travel from source to destination. In a router, latency is the amount of time between when a data packet is received and when it

is retransmitted, the time for a hop. This delay accumulates as the number of routers and the delays at each router increase (“Networking Encyclopedia”, 2003). The primary goal of Quality of Service is to provide priority including dedicated bandwidth, controlled jitter and latency (required by real-time and interactive traffic), and improved loss characteristics for multimedia such as streaming video (“Networking Encyclopedia”, 2003).

Delivery delays can cause problems for applications with real-time requirements, such as those that deliver multimedia, the most demanding of which are two-way applications like videoconferencing (QoS Protocols and Architectures, 1999). Increasing the bandwidth may be a first step for accommodating the real-time applications but it’s still not enough to avoid jitter during the traffic burst. Until recently, TCP/IP networks could only make their best effort to deliver a multimedia transmission by assigning priority to delay sensitive packets such as multimedia but they dropped packets in the event of congestion while managing bandwidth. Best effort is suitable for a wide range of network applications such as general file transfer and e-mail but not multimedia (Dodd, 2002).

QoS protocols that can tolerate delay, jitter and loss are required. QoS does not create bandwidth, but it manages it so it is used more effectively to meet the wide range of applications requirements. There are a number of different QoS protocols.

ReSerVation Protocol (RSVP or integrated services) is a signaling protocol that provides reservation set-up and control to enable the integrated services, intended to provide bandwidth management policy (QoS Protocols and Architectures, 1999). Prioritization (differentiated services or DiffServ) allows classification of network resources according

to bandwidth management criteria (QoS Protocols and Architectures, 1999). In this case, network elements give preferential treatment to classifications identified as having more demanding real-time requirements. The Multi-Protocol Label Switching (MPLS) is similar to DiffServ in some respects, but unlike any other protocols, MPLS resides only on routers and is designed to determine the next router hop (QoS Protocols and Architectures, 1999).

Obviously, not all network transmissions require the highest quality service. A major issue is how the appropriate quality is determined, who controls it (ISPs or individuals), and how different qualities are charged for.

QoS terms are generally defined in terms of network delivery capacity and resource availability not in terms of satisfaction for the end-user (Khirman et al., 2002). Recently, the fundamental assumption behind such traditional provisioning is that measured Quality of Service is related to Quality of Experience (QoE) for the end-user.

According to Vogel et al. (1995), people are the starting point for the overall QoS, thus the primary source for the overall QoS requirements is the user. Some researchers are now calling the result of QoS as experienced by users Quality of Experience (Bauer & Patrick, 2002) to emphasize the difference between the technical capabilities and the user experience. In this paper, the more general term, quality of service, which has been used for years by researchers to refer to user's experience as well as the technical capabilities is used. Nevertheless, this thesis is concerned solely with user experience, not the technology that makes such control possible.

Studies on QoS and Multimedia over the Internet

In the near future, people should be able to make bandwidth choices through Quality of Service (QoS) contracts that will allow viewers to reserve particular levels of bandwidth, in exchange for a fee (Hafid et al., 1995 and Fishburn et al., 1998).

Until recently, most of the research in the area of Multimedia applications and Quality of Service was concerned with technical aspects such as algorithms, protocols or certain characteristics of network performance outside the control or influence of end-users. Recently a number of initiatives have emerged where the primary source of QoS requirements is the user (Vogel, 1997). Some of these studies include proposed user interfaces to allow users to request different levels of quality for different applications.

Proposed User Interfaces

A few studies by researchers at University of Montreal, University of Ottawa and University of Sydney, (Bochmann, Hafid and Dssouli, 1998; Bochmann and Hafid, 1999; Richards and Witana, 1997; Fry, Seneviratne, Vogel and Witana, 1997) proposed user interfaces where the user has control over the QoS. Most of the technical issues were implemented but the studies didn't evaluate the user interfaces and didn't determine users' willingness to control quality as needed and willingness to pay for the quality obtained.

One user interface for controlling QoS, proposed by Bochmann et al. (1999), allows the user who "is the main actor for the specification of the required QoS" to specify requirements for bandwidth delivery. To facilitate QoS specification by users, the authors introduced the notion of user profiles. Figure 2 illustrates the user interface as presented by Bochmann, 1999.

Figure 2. Profile component window for QoS User Interface (Bochmann & Hafid, 1999)

The user profile includes a list of options such as audio, video, image, text, cost and time. As shown in figure 2, the components of the user profile are highlighted. These components describe user preferences in terms of QoS settings for video, audio, still images and text, the cost that the user is willing to pay and the time constraints. The user is able to specify his/her specific preferences. For example, three previously defined profiles are shown for audio quality. In addition, the user can specify relative “importance factors” and indicate the degree of importance of the different QoS

characteristics including the cost. For example, audio might be more important than cost, which is more important than video quality. Another interface proposed by Fry et al. (1997b) allows users to specify if maintaining a high frame rate is more important than maintaining a large image size.

Hafid (as cited by Bochman, 1999) added another option to the user interface. For future re-use, the user would be able to store a QoS profile to avoid the long process of setting the QoS parameters. Thus, when the user starts a session, he might select an already stored profile. The user could also change his/her preferences during a session and have the ability to dynamically control preferences during a session. The user interface proposed by these researchers aimed to express QoS characteristics and parameters in an “understandable language” to users. The user interface and the user profile should hide as much as possible the internal QoS parameters, e.g., throughput and jitter, and provide facilities to describe the requested QoS in terms of user perceived characteristics (Bochmann et al., 1999). Unfortunately, we don’t know if people would be willing to control these quality characteristics or if they know what changing a quality characteristic would do to the streaming media.

The Importance of Paying for Quality

According to Bochmann and Hafid (1999), quality characteristics are related to cost. Without a differential fee schedule for different quality, everyone would opt for highest possible quality with a detrimental impact on overall network performance. A graded fee schedule is essential to maintain network performance. With different costs associated with different levels of quality, some users would decide that quality is much more important than cost, therefore they might pay “any” cost to get the requested

quality. For other users, the cost might not be so important, thus they would accept any “degraded” quality and pay no more than the lowest price. Depending on his/her needs, the user would be able to change his/her preferences regarding the quality characteristics and cost. In other research, Bochmann et al. (1998) considered that the “cost is a key concept that will limit the greediness of the users” (p.37). Without cost constraints, users will ask for the best available QoS so cost of the network will increase.

User Interface for Controlling QoS

In addition to the user interface shown in Figure 2, Bochmann et al., (1997) proposed a complex user interface for adjusting a number of QoS parameters. The user is able to modify his/her preferences by moving a sliding bar and set the desired values for QoS attributes, such as audio profile, video profile and text profile, cost, time and importance (Bochmann et al., 1997). Figure 3 shows the scaling bars for adjusting and controlling the QoS as proposed by Bochmann et al., 1997. The user interface allows users to specify his/her requirements in advance by creating a video quality profile using all the video attributes available: frame rate, number of colors and resolution.

Figure 3: QoS Video Profile User Interface (Bochmann and Hafid, 1997)

In the SuperNOVA project conducted by Antoniades, Richards, Rogers and Witana (1998) at the Distributed Systems Technology Center in Australia, the user interface provides a single slider for controlling the cost. Figure 4 illustrates the user interface design for the SuperNOVA project.

A viewer controls the quality by using a sliding bar from a lower price to a higher price. The quality obtained depends on how much the viewer is willing to pay, and individual quality characteristics are completely hidden from the viewer.

Figure 4: Mapping user QoS from a single parameter (Antoniades, Richards, Rogers and Witana, 1998)

Apteker's (1997) point of view is that adjusting only the cost parameter is too narrow for negotiating QoS because different content types require different audio and video quality settings. On the other hand, the complex user interface may not be usable or useful.

QoS Video Attributes

According to Fry et al., (1997), users should be able to specify the desired QoS in terms of video attributes such as frame rate, image size, number of colors, audio/video synchronization, spatial resolution (Fry & Witana, 1997). At any time during the streaming presentation, the viewer can modify these values depending on needs. Thus, for some viewers, the video color parameter is more important than the video resolution while for others it can be the opposite (Bochmann, 1999). These decisions depend also on the content of the application.

There has been no indication of how viewers deal with these preferences. It is still not known if viewers are able or willing to interact, control video parameters and negotiate the price with the User Interface for achieving the desired quality.

User Needs Assessment for QoS Using Focus Groups

One way to insure that users get the quality of service that they want for multimedia materials over the Internet is to give them control over the quality of service on a dynamic basis at the desktop. This implies that users will want to control quality of service and that they will have a user-interface that allows them to effectively control quality of service. Before such a user interface can be designed, a user-needs assessment could provide valuable information. One user-needs assessment method that has been used for this type of problem is a focus group.

A focus group is one of the research methods for collecting qualitative data. It is a small group interview of six to eight participants where a moderator guides the interview while the group discusses topics that the interviewer raises (Krueger, 1998). The session is recorded on audio or video tape or written down by a note taker.

Focus groups are widely used for social science and market research, but have also been applied to learn about user needs and requirements from potential users, as an effective tool for testing responses of potential customers to new product ideas (Constantine, 1999).

There were a few focus groups conducted where quality of service was the topic of the discussion. One was conducted to investigate users' attitudes for QoS pricing (Bouch and Sasse, 1999) and another one to investigate user perception for Internet QoS (Bouch et al., 2000). However, there are potential problems with focus-group methodology, especially in situations like the quality of service issue where people are unfamiliar with the issues. It is believed that users may have a hard time developing ideas about a product when they have not experienced it or they are far from it (Mayhew, 1999). On the other hand, the use of concrete examples might limit participants to talk only about the examples used. Another question might be regarding to the use of verbal presentation of unknown issues to the participants. For example, a presentation of video quality examples would help participants to talk and evaluate their attitudes towards controlling and paying for QoS. Another challenge would be to help participants understand how they might control the video quality. For example, if focus-group participants thought it would be difficult to control QoS, they might not want the capability to control it. A general question with focus groups is how to get discussants to a level of understanding the issues without being so concrete that they evaluate the specific examples used to convey the issues.

Objectives of the Study

The first objective of this study was to gather user-needs information about streaming media. The study looked at participants' comments and opinions about streaming issues during focus-group discussions. A broader objective was to study methodological problems in the use of focus groups for user-needs assessment.

Participants would be asked about things they might not have experienced before such as desirability and quality of different video frame rates and different degrees of compression on video images, willingness to control quality, and willingness to pay for additional quality. During the focus-group discussion, participants were given different types of information and context on these issues. This information was either a visual demonstration (viewing video samples) or a verbal description (listening to verbal descriptions of what the video would look like) and was provided to help participants understand and talk about QoS issues. Therefore, the second objective of the study was to analyze the effect of using a visual demonstration (video clips of different frame rates and levels of compression) of QoS attributes as opposed to verbal a description in focus groups. The study compared the results obtained as well as opinions of participants who received a visual presentation with participants who received a verbal description of QoS issues.

The other type of information was provided to help them to understand how they might control the video quality. Participants in the focus group talked about controlling the user interface. If they thought that it might be difficult to control the QoS would they think that controlling QoS is less desirable? Did their understanding of controlling QoS have an effect on their comments, questions and their ratings on willingness to control

and pay? Thus, the third objective of the study was to find out if the use of a simple or complex user interface example would have an effect on participants comments and ratings. To address this issue, two types of user interface examples were presented. Half of the focus groups saw an example of a simple user interface to control video attributes while the other half saw a complex user interface that provided control over different attributes. These specific manipulations in this study provide insights into similar problems that might be encountered in any focus group study.

Method

Research Design

A pilot focus group was conducted prior to running the study to test the materials in the discussion guide, equipment and procedure. Eight focus groups were conducted. Four of them received a visual demonstration of QoS issues while the other four received a verbal description of QoS issues.

Two focus groups out of four that saw a visual demonstration saw a complex user interface example for controlling QoS and the other two focus groups saw a simple user interface example. Two of the focus groups that were told about quality of service issues were told about a complex user interface example for controlling the QoS and the other two focus groups were told about a simple user interface.

Table 1 illustrates how the eight focus groups were assigned to each of the four types of focus groups.

Table 1

Focus-group conditions

	Video demonstration of quality	Verbal description of quality
Complex User Interface example	2 Focus Groups	2 Focus Groups
Simple User Interface example	2 Focus Groups	2 Focus Groups

Thus, the 2 by 2 completely between-groups factorial design consisted of two independent variables: video quality examples (visual demonstration versus verbal

description) and the user interface examples (simple user interface versus complex user interface) with two groups in each combination.

Participants

In response to public notices, 48 participants were assigned to the focus groups. Participation was voluntary and participants were paid \$15. The announcement for recruiting is provided in Appendix A. Once a group of six people was formed, a focus group was conducted. Not all the assigned participants showed up. Forty-one students actually participated in the eight focus groups. All participants said they were Internet users who reported that they watched video and audio over the Internet.

The table bellow illustrates the number of participants in each type of focus group.

Table 2

Number of participants for each focus group

Focus group number	Number of participants for each focus group (N = 41)	Number of participants for each condition	Video quality example	User Interface example	
1	4	N= 9	Visual demonstration	Complex user interface	
2	5	N= 11		Verbal description	Simple user interface
3	5				Simple user interface
4	6				
5	6	N=12	Complex user interface		
6	6	N= 9		Simple user interface	
7	5				
8	4				

Material

Focus Groups were held in the Cognos HCI Lab at Carleton University. The focus group room was equipped with an oval central table and ten chairs, placed around the table. Participants wore nametags.

A computer with AMD Athlon 1.8 GHz processor controlled a data projector that displayed the visual demonstrations on 50 inches by 38 inches wall-mounted screen. The demonstration consisted in a presentation of three types of video content. The three different video clips were a hip-hop dance, a movie and a fast action with children running. Each video content type was presented in two ways: low video quality and high video quality. For the low video quality, each video clip had low frame rate and poor resolution, while for the high video quality, each video clip had higher frame rate and higher resolution. A screen capture of all the video clips can be found in Appendix B.

For the verbal description of the video quality issues, I described these differences without showing any example. The descriptions of the video quality examples are part of the moderator guide as shown in Appendix C.

A second demonstration was a presentation of two user interface examples. The first example was a simple user interface with one sliding bar for controlling the video quality and dollar signs at both ends of the bar. The second example was a complex user interface with five sliding bars for controlling the following video quality attributes: color, frame rate, video and audio audio/video synchronization, image size and resolution. At both ends of each sliding bar was placed a dollar sign. The user interface examples are shown in Appendix D.

Of the four focus groups that saw a visual demonstration of video quality examples, two focus groups saw a complex user interface example and the other two focus groups saw a simple user interface example. The other four focus groups listened to a verbal description of either a simple user interface example or complex user interface example. The descriptions of the user interface examples are shown in Appendix C.

I used a flipchart at one end of the table to write down participants' examples of video streaming during the discussions. A microphone was placed in the center of the table and four video cameras were mounted on the walls to record video and audio of the sessions. In addition, a tape recorder was placed on the table to audio record the discussions.

A background questionnaire, shown in Appendix E, was used at the beginning of the focus-group discussions. In this questionnaire, participants were asked six questions. Three questions covered their Internet usage, the type of Internet connection used and the purpose of using the Internet. For the first two questions, participants were asked to circle one from six alternatives which best described them. For the third question, participants were asked to choose all the alternatives that best described their purpose of using the Internet. Next three questions covered participants experience with watching video and audio over the Internet as follows. First, they were asked whether or not they listened to or watched audio and video over the Internet. The next two questions required participants to circle all the alternatives that best described them as streaming media users.

Three rating scales, from 0 to 100, were used to measure user attitudes towards QoS. Participants were asked to rate the importance of controlling QoS, their willingness

to control QoS and their willingness to pay. Zero was used to indicate very unimportant to control, very unwilling to control and very unwilling to pay, and 100 was used to indicate very important to control, very willing to control and very willing to pay. A neutral point was placed in the middle of each rating scale. Rating scales are shown in Appendix F.

Procedure

Upon arrival at the focus-group room, I welcomed participants and verified their names from the list of people who volunteered to participate in the focus-group session. Participants were asked to sign an informed consent form, shown in Appendix G, where they were asked for permission to video and audio tape the session. They were asked to fill out the background questionnaire, shown in Appendix E, about their Internet usage and their use of video and audio streaming.

After the completion of the background questionnaire, participants were given a brief introduction about the focus group and general instructions about the discussion, shown in Appendix C.

Before starting the discussion, participants introduced themselves, described briefly what they used the Internet for and what type of Internet connection they had. Once the participants finished introducing themselves, I introduced the topic of the discussion and I gave them a short definition of streaming media, shown in Appendix C. After introducing the topic, I followed a set of steps for all focus groups. The steps covered during focus-group discussions are presented in Table 3. The moderator guides for each type of focus group can be found in Appendix C. The only difference in steps was in the type of group in which the focus groups were assigned, either the visual

demonstration group versus the verbal description group or the simple interface group versus the complex user interface group. Minor differences arose from changing the order of the questions due to participants' level of understanding, their streaming video experience, and their knowledge about streaming media.

Table 3

Steps in the focus-group discussion

Step	Description	Type of focus group
1	Participants were asked to share examples of streaming media	All
2	Moderator explained the differences between streaming media and "downloading and playing" and the advantages and disadvantages of each of them	All
3	Participants were asked for more examples of streaming media	All
4	Moderator used the examples to talk about video characteristics: frame rate, synchronization, resolution, color and image size	All
5	Moderator introduced the payment's options and the controlling QoS topic	All
6	Discussion about paying and controlling QoS	All
7	Visual demonstration or verbal description	Depended on group
8	Discussion	All
9	Rating scales	All
10	Complex or simple user interface example	Depended on group
11	Discussion	All
12	Rating scales	All

Step one: Participants shared examples. Participants were asked to share examples of streaming media. The purpose of this step was to identify their level of understanding and their level of knowledge regarding the concept of streaming media. All participants were asked to share an example from their experience. I wrote all the examples on the flipchart.

Step two: Differences between streaming media and downloading. I grouped the examples in two categories and explained the differences between streaming media versus downloading and playing, and the advantages and disadvantages of each of them. The purpose of the explanation was to clarify the two different concepts.

Step three: More examples of streaming media. I asked participants to provide more examples of streaming media. The purpose of this question was to ensure that participants understood the concepts and to focus the discussion on streaming media.

Step four: Use examples to discuss video characteristics. I used participants' examples to bring up and define the following video streaming attributes: frame rate, synchronization between audio and video, resolution, image size and color. The purpose of this discussion was first, to ensure that participants understood the streaming media issues and second, to ensure that they were able to participate with their opinions and comments in the next steps of the discussion. Participants were also asked to explain each video characteristic. They were asked to provide examples of streaming media content or circumstances when they might need higher or lower frame rates, where audio/video synchronization and resolution are important, when they might need more or less colors, and when bigger or smaller image size might be desirable. The purpose of this discussion

was to ensure that participants understood controlling and paying more for better quality and to prepare participants for the next step.

Step five: Introduce controlling and paying for quality. After clarifying and explaining each video characteristic, the topic of payment and controlling these video characteristics was introduced. I presented and wrote down on the flip chart three possible payment options. The first option was a low monthly standard fee for Internet connection. This option is good for web surfing and e-mail but not good for watching streaming video and audio.

The second option was a monthly higher fee for high speed. This option is much better for streaming media but the quality is not guaranteed. The third option was a standard fee for surfing the web and the use of email that don't require a lot of bandwidth but with the possibility to pay more for more bandwidth any time when the users would like to watch streaming media.

This third option was called "pay per view" and it gave the possibility of having higher quality and the dynamic control of the video streaming attributes like: higher frame rates, more resolution, larger image size, more audio/video synchronization and more colors.

Step six: Discussion about "pay per view." Participants were asked to focus on the third option of payment, the "pay per view", and share their opinions and comments about controlling video characteristics and paying more for better quality. All participants were invited to share their points of views.

Step seven: Visual or verbal presentation of Video Quality Examples. After all the participants had the opportunity to share their opinions about the "pay per view" option, I

emphasized the differences between a low and a high video quality by presenting either visually or verbally three different types of video content. The first purpose of this demonstration was, to see if there is a difference in willingness to pay and control the video settings between participants who viewed a visual demonstration and participants who received a verbal description of different qualities. The second purpose was to ensure that participants had more opportunities to be exposed to different examples and to engage in the discussion by sharing their points of view. The screen captures of video quality examples are shown in Appendix B. The verbal description of the video quality examples can be found in Appendix C.

Step eight: Discussion. After either seeing the visual demonstration or listening to the verbal description, participants were asked to continue the discussion by sharing their points of views about controlling the video settings and paying more to obtain a better quality.

Step nine: First set of rating scales. Participants received the first set of rating scales shown in Appendix F. Based on the previous discussion about controlling video settings and paying more to obtain better quality, participants were asked to rate the importance of having quality controls for each video setting, their willingness to control these settings and their willingness to pay more to obtain better quality. An example and instructions on how to do the ratings were provided.

Step ten: The user interface example. Half of the participants within the groups that received a video demonstration saw a complex user interface example as a way for controlling video settings and the other half of participants saw a simple user interface example. In the case of the groups who received a verbal description of the QoS issues,

half of the participants were told about the simple user interface example and the other half of the participants were told about a complex user interface. The user interface examples can be found in Appendix D and the verbal description of the user interface example can be found in Appendix C.

Step eleven: Discussion. After they either saw the user interface example or the user interfaces were verbally described, participants were asked to continue the discussion by sharing their points of view.

Step twelve: Second set of rating scales. Keeping in mind the idea of the user interface as a way of controlling the video settings, participants were again asked to rate the importance of having quality controls for each video setting, their willingness to control these settings and their willingness to pay more to obtain better quality.

After completing the second round of rating scales, shown in Appendix F, participants were debriefed about the purpose of the discussion and thanked for participating in the study. The debriefing form is shown in Appendix H.

Results

Background Questionnaires Analysis

The analyses of the background questionnaire show that all participants had Internet connection and used the Internet daily. Twenty-four participants used cable high-speed Internet connection; 12 participants used DSL high-speed Internet connection; 5 participants used dial-up Internet connection. All of the participants except one listened to audio or viewed video over the Internet. Although the recruitment protocol stated that participants should have watched audio and video over the Internet, the analysis of the background questionnaire showed that one participant did not listen to audio or view video over the Internet. The background questionnaire was given at the beginning of the session and followed immediately by the discussion. There was not time to analyse participants' responses therefore this participant was included.

Regarding the type of video content watched over the Internet, 35 participants responded that they had watched music videos over the Internet, 29 participants had watched movies, twelve participants had watched sporting events and nine participants had watched news.

Thirty-two participants used Windows Media Player, 17 participants used Real Player, and 16 used Quick Time. DivX and Winamp were other types of players given as an example by 6 participants.

All participants used the Internet for searching information, education, and email. All except 2 participants used the Internet for entertainment. Seventeen participants used

the Internet for purchasing on-line, 3 for stocks, 3 for chat and 2 participants used the Internet for banking.

Data Analysis

Quantitative and qualitative data were analyzed. Quantitative analyses were conducted on participants' ratings about QoS for a number of different video streaming characteristics. Qualitative analyses were performed on comments.

A five-way mixed factorial ANOVA was used to analyse quantitative data. The experimental design is shown in Table 4. The two between-group variables were video quality example (visual demonstration versus verbal description) and user interface example (simple user interface for controlling QoS versus complex user interface for controlling QoS). There were three within-subjects variables. The first within-subjects variable was order of ratings (ratings obtained before participants saw the user interface example and ratings obtained after participants saw the user interface example). The second within-subjects variable was the five attributes to be controlled to obtain video quality (number of different colors that can be seen, frame rate or the number of still pictures displayed per second, image size or the number of pixels contained in each frame, audio/video synchronization, and resolution or clarity of the image). The third within-subjects variable was the three rating scales of user attitudes toward QoS for the five attributes (importance of controlling QoS, willingness to control QoS and willingness to pay for QoS). Participants used rating scales from 0 to 100 to indicate attitudes towards QoS for the five streaming attributes.

As is typical in focus groups (Krueger, 1998), each focus group was considered a subject. Thus, the ratings for each focus group are the means obtained from the participants in the group and the sample size is treated as the number of focus groups, eight. Table 4 shows the experimental design.

Table 4

Experimental Design

		Before UI example					After UI example						
		Color	Frame rate	Image size	A/V Synch ronizat ion	Resolu tion	Color	Frame rate	Image size	A/V Synch ronizat ion	Resolu tion		
		I	C	P	I	C	P	I	C	P	I	C	P
Visual demon stration	Simple UI												
	Complex UI												
Verbal descrip tion	Simple UI												
	Complex UI												

Note: I = Importance of controlling QoS rating scale, C = Willingness to control QoS rating scale, P = willingness to pay QoS rating scale

The analysis of variance summary table for the mixed factorial design can be found in Appendix I. Significant main effects were followed by multiple comparisons using the Bonferroni correction to protect against making too many Type I errors. Significant interactions were examined by performing simple main effect analyses, which were followed by multiple comparisons if the simple main effects were significant.

Because Mauchly's test indicated that the sphericity assumption was not violated for any within subject main effect or interaction involving a within subject independent

variable, conventional univariate analyses were used. Results that were significant are presented.

In addition to quantitative analyses, qualitative analyses were conducted on transcripts of participants' comments and opinions during the focus-group discussions. These comments are presented to support the rating scale analyses.

User attitudes towards different aspects of QoS and controlling attributes

Collapsing over all other independent variables, there were differences in user attitudes towards QoS, $F_{(2, 8)} = 28.13, p < .01$. The means for each rating scale are illustrated in Figure 5.

Figure 5. Mean rating for importance of controlling QoS, willingness to control QoS and willingness to pay for QoS

On the vertical axis are ratings from 0 to 100. The three bars represent the three different scales used for rating user attitudes towards QoS. The three means are obtained by collapsing ratings over video streaming attributes, the order of getting ratings, the user interface examples and the video quality examples. Table 1 from Appendix N shows the means and standard errors for importance of controlling, willingness to control and willingness to pay.

Pairwise comparisons using the Bonferroni correction showed that ratings of the importance of controlling QoS did not differ from the willingness to control QoS but both were rated significantly higher than willingness to pay for QoS. Thus, in general, participants thought it was relatively important to control quality of service and they were willing to control it, but they were not nearly as willing to pay to have better quality of service. On the other hand, mean rating of willingness to pay ($M=52.55$) was approximately neutral and not in the unwilling-to-pay range.

Participants' comments about user attitudes towards QoS

During the focus-group discussions participants made comments about importance of controlling, willingness to control and willingness to pay for video quality.

Table 5, Table 6 and Table 7 list all the reasons for being or not being important to control, willing or not willing to control, willing or not willing to pay for better video quality.

Table 5

Important or not important to control the quality

Reasons for importance of controlling	Reasons for not being important to control
It is important to control the quality to see the differences between a high and a low quality, to see the differences between a fuzzy picture and a clear one. (4 participants)	There is no need to control the quality because quality should always be the highest. (1 participant)
It is important to control because they wouldn't watch something too blocky. (1 participant)	

Table 6

Willing or not willing to control

Reasons for willing to control	Reasons for not willing to control
It's good that streaming media offers possibility to control, e.g. increase the frame rate and resolution. (8 participants)	It's too much to think about because of the lack of technical knowledge. (3 participants)
They are willing to control video quality for movies, sporting events or action in general, but not for news. (2 participants)	
They would like to control the quality but not to pay for it. (1 participant)	

Table 7

Willing or not willing to pay

Reasons for willing to pay	Reasons for not willing to pay
If streaming media offers something unique, exclusive or something different in terms of content than the TV. (9 participants)	“Pay per view” might be more expensive for students than the high monthly fee if watching streaming media a lot. Therefore the flat rate and a lower quality work better. (11 participants)
If it offers the best quality or the same as the TV quality. (7 participants)	It’s too much to think about how much they are going to pay when watching streaming media. There is a need to calculate cost any time when using streaming media. (6 participants)
Prefer to watch and pay for streaming media only if it’s a substitute for TV when there is no TV, cable or satellite. (2 participants)	Concerned about paying twice for Internet connection and for streaming media. The high monthly fee already covers not just streaming media but downloading options. (5 participants)
	Don’t like the whole “pay per view” concept of paying because they considered it not important and not a necessity. (3 participants)

Users attitudes towards controlling the streaming video attributes

Participants rated five separate video attributes: color, frame rate, image size, audio/video synchronization, and resolution. There were significant differences in ratings for the five video attributes, shown in Figure 6, $F_{(4, 16)} = 15.78, p < .05$.

Figure 6. Mean rating for streaming video attributes

On the vertical axis are ratings from 0 to 100. The five bars on the horizontal axis represent the five different attributes that were rated. The means were obtained by collapsing over the three rating scales representing the user attitudes towards QoS, the order of getting ratings, the user interface examples and the video quality examples. Table 2 from Appendix N shows the means and standard errors for color, frame rate, image size, A/V synchronization and resolution.

Multiple comparisons generally indicated that participants felt that color was not as important to control as the other streaming characteristics.

Participants' comments about video streaming attributes

In step three of the discussion, participants were asked to provide more examples of streaming media. At that time, participants had already started to use examples to talk about video streaming attributes. Frame rate and audio/video synchronization were mentioned the most in participants' examples whereas color was not mentioned at all. Audio quality was mentioned as well. Other streaming attributes barely mentioned were image size and resolution. Table 8 presents the video streaming attributes brought up as examples during the discussion, the description of each of these attributes, and how many times these examples were mentioned in the discussion.

Table 8

Number of video streaming attributes examples, description and frequency

Video streaming attributes	Description	Frequency
Frame rate	It is pixelated, choppy, blocky, it goes frame by frame, is not fast enough, it pauses and it skips little sections.	11
Image size	It's not designed for full screen, it's too small and when the image is big it's worse.	3
Audio/video synchronization	It has sound but not picture; audio keeps going but the video stops; audio is played entirely but video in half; the sound and the audio don't match up.	11
Resolution	The whole screen is blocky and the resolution is fuzzy.	1
Audio quality	Audio sound is scratchy and it is set up for a specific volume.	3

In step 4 of the discussion, participants' examples of streaming media were used to talk about video streaming attributes. Table 9 shows what participants said about each video attribute, including when is important or not important to have high quality in each of these video streaming attributes.

Table 9

Important/not important to have video streaming characteristics

Video streaming characteristics	Important to have	Not important to have
Good Color	It enhances the video, it's a bonus; it is good for something that involves interpretation, i.e. movies (3 participants), online games (1 participant) or maps (1 participant).	It's not necessary and not important for news (2 participants) and courses online (1 participant).
High frame rate	Good for lot of action and motion i.e. movies (6 participants), sporting events (6 participants), video conferencing (1 participant), music video (1 participant), online courses (1 participant).	It's not important for news (4 participants), stock online (1 participant), slide shows (1 participant), web camera (1 participant).
Large image size	Useful when watching movies on the computer (4 participants); it's good for details and graphic (1 participant).	It is not important for news (1 participant).

Table Continues

Good Audio/Video synchronization	In is always necessary for sporting events (7 participants), movies (2 participants), news (2 participants), music video (2 participants), live meetings (1 participant), web camera (1 participant).	
High resolution	It's good for text, sporting events, movies, documentaries, and music video. (2 participants)	Not important for news (2 participants), sporting events (2 participants), music video (2 participants).

Interaction of video streaming attributes and user attitudes towards QoS

Participant's ratings of the five attributes depended on which of the three user attitudes towards QoS scales they were rating, as indicated in Figure 7. On the vertical axis are rating scale scores from 0 to 100. The three lines indicate the scale rated. The top line represents the mean user ratings for importance of controlling QoS rating for each streaming video attributes. The middle line represents the mean user willingness to control QoS rating for each video attribute. The lower line represents the willingness to pay for QoS rating for each streaming video attribute.

Figure 7. Interaction between video attributes and user attitudes towards QoS

The interaction between user attitudes towards QoS (importance of controlling QoS, willingness to control QoS and willingness to pay) and video attributes (frame rate, color, image size, synchronization and resolution), shown in Figure 7, was significant, $F_{(8,32)} = 9.53, p < .01$.

The three lines represent the importance of controlling, willingness to control and willingness to pay plotted for all five video streaming attributes (color, frame rate, image size, audio/video synchronization and resolution). These means were obtained by collapsing over the order of getting ratings, the video quality examples and the user interface examples. Table 3 from Appendix N shows the means and standard errors for the interaction between user attitudes towards QoS and video streaming attributes.

A series of multiple comparisons were performed to understand the interaction in Figure 7. The first set of comparisons looked at differences in ratings of user attitudes towards QoS (importance of controlling, willingness to control and willingness to pay) separately for each video attribute (color, frame rate, image size, synchronization, and resolution). For all the video attributes, participants' rating for importance of controlling color, frame rate, image size, audio/video synchronization and resolution was higher than participants' rating for willingness to pay for all the video attributes, all $p < .001$. Participants considered that it is important to control all the video attributes but they were not as willing to pay for any of them. Participants rated willingness to control lower than importance to control for color, $p < .001$, and audio/visual synchronization, $p < .001$, but not frame rate, image size and resolution. Also, they rated willingness to control higher than willingness to pay for all video streaming attributes, $p < .001$, except color.

Multiple comparisons were also done to see the differences among video attributes for each scale separately. In the top line, participants' ratings for importance of controlling synchronization ($M=90.25$) and resolution ($M=83.58$) were higher than participants' rating for importance of controlling color ($M=64.69$), $p < .005$. Also participants' importance of controlling resolution ($M=83.58$) was rated higher than participants' importance of controlling image size ($M=80.16$), $p < .005$.

In the middle line, for willingness to control QoS, there were no significant differences among video attributes. In the bottom line representing the willingness to pay, there were significant differences among video attributes. Participants' rating for willingness to pay for frame rate ($M=55.36$), for synchronization between video and audio ($M=58.01$) and for resolution ($M=56.99$) were higher than participants' rating for

willingness to pay for color ($M=39.87$), $p<.005$. No other differences among streaming video attributes were significant on any of the three rating scales.

Participants' comments about the interaction between user attitudes towards QoS and video streaming attributes

Two participants (one from the focus group with visual demonstration of QoS and the complex user interface example and another one from the verbal description of QoS and the simple user interface example) made comments about their willingness to control video streaming attributes. One participant said that it is necessary to control because “the color is less important than the synchronization” and “there is a need to stabilize” what they are paying for. Another participant thought that there is a need for controlling video streaming attributes because, for example, the color can be sacrificed for more frame rates or the image size may be important for some people whereas audio/video synchronization might be important for others. No other comments that support the result obtained for the user attitudes towards audio/video synchronization were made.

Analyses involving video quality examples and the order of completing the rating scales

Half of the focus groups were shown visual examples of QoS issues and half of the focus groups were told about the QoS issues. The purpose of using different presentations of quality issues was to see if participants' understanding of QoS issues and their attitudes and evaluation towards QoS depended on the information they received, either visual or verbal. The main effect of the video quality examples (visual demonstration versus verbal description) was not significant, $F<1$.

Participants were asked to rate their user attitudes towards QoS twice: before the user interface example was presented during the discussion, and then again after the user interface example was presented. The primary purpose of including two rating opportunities was to see if there was a difference in the first set of ratings and the second set of ratings that depended on the user interface examples that were shown or verbally described. The main effect of order of the ratings (before or after the user interfaces were presented) was not significant $F_{(1,4)} = 2.52, p > .05$.

The two-way interaction between the video quality example (visual demonstration versus verbal presentation) and the order of ratings (before presenting the user interface example and after presenting the user interface example) was significant, $F_{(1,4)} = 8.78, p < .05$. This interaction is illustrated in Figure 8. The vertical axis shows the rating scales. Data points are the mean ratings, collapsed across all three scales (importance of controlling, willingness to control and willingness to pay). Data points are the mean ratings, collapsed across all three scales (importance of controlling, willingness to control and willingness to pay), video streaming attributes and the user interface examples. Table 4 from Appendix N shows the means and standard errors for the interaction between video quality examples and the order of completing the rating scales.

The horizontal axis shows ratings before the user interface demonstration and after the user interface demonstration. The type of video quality example, either visual demonstration (squares) or verbal presentation (circles), is shown as separate lines.

Figure 8. Interaction between the order of ratings (before presenting the user interface example versus after presenting the user interface example) and the video quality example (visual versus verbal).

Participants who saw a visual demonstration of QoS issues rated their attitudes towards QoS higher before they saw the user interface example ($M = 70.38$) than after they saw the user interface example ($M = 61.93$). No other significant differences were found, i.e., ratings for the visual and verbal examples were statistically equivalent on the first rating and on the second rating.

Analyses involving the video quality example and the user interface example

Four groups saw a visual demonstration of QoS issues and the other four groups heard a verbal description of the QoS issues. Within the four groups who received a visual demonstration, two groups saw a simple user interface example and two groups saw a complex user interface example. Within the four groups who were told about the

QoS issues, two of them were told about a simple user interface example and the other two groups were told about a complex user interface example. The objective was to see if participants' evaluation and attitudes towards QoS would depend on their understanding of controlling QoS using either a complex or a simple user interface.

The main effect of user interface example (simple user interface versus complex user interface) was not significant, $F < 1$, and, as described above, the main effect of video quality example was not significant. However, the interaction between the video quality example and user interface example was significant $F_{(1, 4)} = 10.24, p < .05$. This interaction is shown in Figure 9. The ratings are shown on the vertical axis. Data points are mean ratings, collapsed across the order of ratings (before presenting the user interface example and after presenting the user interface example), the rating scales and the video streaming attributes. Table 5 from Appendix N shows the means and standard errors for the interaction between video quality examples and the order of completing the rating scales.

Although the interaction was significant, the interaction is impossible to interpret because none of the possible multiple comparisons in Figure 9 were significant when the Bonferroni correction was used. In addition, the results seem to be partly counter intuitive. Those who saw a video example of quality rated controlling and paying for better quality slightly higher after seeing a complex user interface. These results are even more unclear because the demonstration of the user interface should have had an effect only after the demonstration was given, but the three way interaction between video quality example (visual or description), user interface examples (simple or complex) and order of rating (before user interface example or after) was not significant, $F_{(1, 4)} = 2.90$,

$p > .05$. This pattern of nonsignificant, ambiguous and contradictory results suggests that there is no evidence that the user interface examples had any systematic impact on ratings.

Figure 9. Interaction between the video quality example (visual versus verbal) and the user interface example (simple versus complex).

Participants' comments involving the video quality examples and user interface examples

Participants made a number of comments after presenting the user interface examples. There were four different types of focus groups. Table 10 lists the comments that participants from all types of focus groups made about the user interface examples presented. Comments and frequencies are listed below.

Table 10

Comments about the user interface examples and frequencies

Comments about the user interface for controlling video streaming attributes	Frequency
Prefer a simple user interface with no more than five sliding bars.	1
One sliding bar looks very simple but “it actually limits the possibility to control what you want: e.g. frame rate or color.”	2
Prefer to preview the differences between a high and a low quality or a preview of video quality. The preview should be located at the top of the sliding bars.	3
Prefer to preview the price and compare the price between a high and a low quality.	2
The interface should have three options for a high, medium and low quality instead of sliding bars. The user should be able to control the quality with a few clicks.	2
One sliding bar is useful for people who are not knowledgeable about video streaming attributes. Sliding bars should be available for all video streaming attributes. The interface should have basic and advanced features “like any software program.” The interface should consider all types of users and have basic and advanced options.	3
Buttons are better than sliding bars so that, for example, a button for a sporting event “will emphasize the frame rate or synchronization, and for a movie it will adjust what’s necessary for it.” Users would like to click on a button rather than moving a sliding bar. Provide presets or suggestions so that inexperienced users would know what’s good for a movie or a sporting event. Companies who are providing the streaming media content should suggest what is best in terms of quality.	3
Users should have their own preferences.	1
Users should be able to see what they are doing and get feedback while controlling the quality.	1
Users didn’t like that the sliding bar indicates the cost.	1

The small number of comments about the user interface and the similarity of comments regardless of the combination of quality examples and user interface examples support the conclusion that the type of user interface had little effect on ratings of controlling quality and paying for quality

Other Significant Results

Three three-way interactions were significant, but are uninterruptible. Appendix J shows the interaction between order of getting ratings (before presenting the user interface example and after presenting the user interface example), video streaming attributes (color, frame rate, image size, audio/video synchronization and resolution) and user interface examples (simple and complex), $F_{(4,16)} = 3.50, p < .05$. Appendix K shows the three-way interaction between order of getting ratings (before presenting the user interface example and after presenting the user interface example), user attitudes towards QoS (importance of controlling QoS rating scale, willingness to control QoS and willingness to pay for QoS) and the video quality examples (visual demonstration versus verbal description), $F_{(2,8)} = 4.83, p < .05$. Appendix L shows the interaction between video streaming attributes, user attitudes towards QoS and video quality examples, $F_{(8,32)} = 2.28, p < .05$.

Other Comments Given by the Participants

During the focus-group discussions, participants made a number of comments that go beyond the quantitative results for the formal experimental design. The most important comments are grouped into categories and presented below. All other specific comments are listed from table 1 to table 3 in Appendix M.

Comments about the “pay per view” fees

There was no price or number mentioned when I presented the three possible methods of payment. Participants were asked to comment about the third method of payment, the “pay per view” method. During the discussion participants came up with different numbers as possible fees. Mixed opinions were expressed regarding the “pay per view” fees. Table 11 presents the possible Internet connection fees proposed by participants as well as the reasons for paying or not paying that fee.

Table 11

Reason for paying/not paying the proposed fee

Reasons for paying the proposed fee	Reasons for not paying the proposed fee
“It would be good to pay \$20 dollars per month for Internet connection, then a couple of dollars for pay per view; you click a few buttons then pay \$3; pay one time for Internet connection then extra bucks for streaming media.” (3 participants)	“Instead of spending \$3 every time when you watch streaming media, I would use the high monthly fee; otherwise at the end of the month you end up paying more.” (2 participants)
“It’s good to spend \$10 once because the TV doesn’t cover something; it is good to have both, the TV and streaming media.” (1 participant)	“If it’s 10 cents per minute, it’s better to go for the high monthly fee.” (1 participant)
“It is more convenient to add a couple of bucks to the standard fee.” (1 participant)	“If \$20 is the standard monthly fee and \$10 a game and another \$10 for another game, it’s not good.” (1 participant)
“If it’s \$20 standard fee and \$5 dollars for 2 hours of streaming media once in a while, then it’s worth.” (1 participant)	”To pay \$1 for frame rate, \$2 for resolution? I don’t know.” (2 participants)

Participants’ questions and concerns

Participants asked questions and expressed concerns about the method of controlling and paying for streaming media, in particular about the “pay per view” method. The list of questions and concerns from participants’ discussions is presented in Table 12. The list of concerns is presented as “what if” types of questions or as scenarios.

Table 12

Questions and concerns from participants

Questions	Concerns
“Do I have to pay to the Internet Service Provider or to the website that is providing streaming media?” (4 participants)	“What if everyone is watching streaming media in the same time? How would they guarantee the quality to everyone?” (3 participants)
“How easy is to subscribe for this service? How does it work?” (3 participants)	“What if you pay to the website and the provider doesn’t give you the quality. It’s the ISP’s job to give you the bandwidth that you need?”
“Is the pay per view only available for high speed or for all? Can you have “pay per view” with dial-up, or just high-speed?” (2 participants)	“What if both the Internet Service Providers and streaming media companies, offer pay per view? Can you choose the best deal?”
“Do you pay for each setting, for each individual thing or just for streaming media?” (2 participants)	“What if a thunderstorm starts and it freezes the computer while you are watching streaming media?”
“How do they control the quality? If it’s choppy and bad, are they going to give you the money back?”	
“What are you sacrificing when you control? If you choose black and white, do you get a better resolution?”	
“Do I have to subscribe for this service?”	

Participants’ suggestions

Participants not only asked questions but also proposed solutions and provided suggestions on how people should pay for streaming media. Their suggestions are presented in Table 13.

Table 13

Participants' suggestions

Suggestions	Frequency
Payment should be made to those “who are providing the frame rate”, which means the Internet Service Providers; otherwise they will end-up paying twice, to the provider and to the website that is providing the streaming media content. The ISPs should monitor and charge the user. Streaming media websites might not guarantee the quality therefore it should be an agreement between those two.	4 participants
“Pay per view” should provide the best quality, best resolution, high synchronization, color; this should be a standard.	2 participants
If payment is made to the website it should be right away; if payment is made to the provider then it can be either at the end of the month or as a membership per week or per month instead of paying any time when using streaming media.	2 participants
They have to limit the number of people who are using streaming media and to build up a good reputation so that people would trust them.	1 participant

Analogies and comparisons

During the focus-group discussion, participants made analogies and comparisons.

The list of analogies and the type of analogy are presented in Table 14.

Table 14

Analogies

Analogies	Type of analogy
The “pay per view” method looks like a phone card, with certain amount of minutes like the “pay per use” or “pay and talk” option, or like the “pay per view” on a TV. (2 participants)	About “pay per view” method
They recommended a program installed on a computer, which can track the users while they are using streaming media the same as the use of cell phone while roaming. In this way users could be charged at the end of the month.	About monitoring the users
Participants preferred to have high video quality in the same way they much prefer to have the CD quality than the audiotape quality, or the DVD quality than the TV quality.	About video quality
Controlling the user interface with a sliding bar is the same as controlling the heat in the house. By using this method, people will be able to control it and associate the difference with a dollar value.	About controlling the quality
While adjusting the quality, users should see what they are doing, in the same way as adjusting the brightness of the monitor.	About controlling the quality

Discussion

The study was conducted to find opinions from users to get requirements used to design a user interface that allows them to dynamically control QoS for streaming media on their desktops and to examine selected methodological issues with focus groups.

This is an early effort in user needs analysis for a QoS user interface. Other research methods like interviews, task analysis or observations should be used to supplement this preliminary information.

User Attitudes about QoS and Video Attributes

Participants considered that it is important to control QoS and they indicated a willingness to control it, but they were not as willing to pay for it. However, even the mean ratings for willingness to pay for quality are not excessively low. As might be expected, participants were, with a few exceptions, unconcerned about the role that a fee structure might play in keeping usage down for the good of all users. Many participants wanted as much bandwidth as they could get and were willing to pay a reasonable monthly fee, without having to think about controlling quality or how much it would cost.

The reserved willingness to pay for QoS can be attributed, at least in part, to the fact that focus-group discussions were conducted with students and students are afraid that the cost might be too high for them. Even if they understood the necessity of paying for more frame rates, for better audio/video synchronization or for better resolution, participants presented many reasons for not being willing to pay for better quality, as presented in Table 7 and Table 12.

Evaluations for frame rate, image size, resolution, and audio/visual synchronization were almost the same but color was rated lower. In early discussions, many attributes that can affect video quality were mentioned, but color was never mentioned. In subsequent discussions dedicated to the importance of each video streaming attribute, color was described as a bonus or an enhancement of the video quality, while the other four streaming attributes were considered important. It is as if the participants took adequate color for granted and never considered the possibility that lower color resolution was possible or higher color resolution was worth having. This suggests the possibility that many computer users may not know what color resolution they have on their displays or, alternatively, they may not be able to tell the difference between 16, 24 and 32 bits of color. It appears that less than 16 bits, for example the 8-bit palettes that dominated the early days of desktop computing, are not even considered. If this interpretation is correct, these results address a common problem faced by web site designers – whether to use limited number of colors or not on web site images. The emphasis on using a color-safe 8-bit palette on web sites seems to be unnecessary. It seems that 8-bit colour displays may not be very common.

User attitudes towards controlling five streaming video attributes were evaluated in relation to user attitudes towards QoS. Although this interaction, shown in Figure 7, was significant, it appears that the interaction is primarily attributable to the ratings for audio/visual synchronization. The generalization that participants considered the attributes important to control and they are willing to control them but they are not as willing to pay for them applies for all the attributes except audio/visual synchronization. It is unclear why, relative to the other four attributes, there was an increase in the

importance of controlling audio/visual synchronization but a decrease in willingness to control it. In the discussion about streaming video attributes, a number of participants indicated that it is very important to have good audio/video synchronization. This emphasis on synchronization during the discussion could account for the higher importance to control synchronization, but it can't account for the lower willingness to control it. The comments did not help explain this unusual result.

Requirements for QoS controls in the User Interface

Based on the results obtained, comments and my judgement, the following requirements and recommendations for designing the user interface and for a payment structure are offered for controlling QoS at the desktop. One of the main findings from the focus-group discussions was that there was little agreement on any aspect of the user interface to control QoS. I conclude that no single user interface can satisfy all users. Therefore, I propose a simple user interface by default and with an option for more complete control with a more complex user interface.

1. The simple user interface should consist of a simple slider

In the default user interface for controlling video quality, there should be a single sliding bar that controls all the video attributes. This was recommended for novice users, or, as it was said during the discussions about the user interface, for people who are not knowledgeable about streaming media.

It was also recommended that the user interface should be kept simple to ensure that the users can control the quality with "just a few clicks."

2. *Labels on the slider should indicate quality, not cost*

One way to achieve simplicity of control is to have a sliding bar with a continuous scale with labels indicating quality rather than cost. A few participants didn't like the idea that the sliding bar indicates cost. It is also recommended to provide the capability to dynamically change among labels that indicate quality and labels that indicate cost.

3. *The fixed monthly payment should be the default payment method for higher quality*

Most users would like to pay a reasonable monthly fee for higher quality and avoid paying each time they watch streaming media. An optional, higher monthly fee will allow users to have a higher video streaming quality, and the possibility to download files faster.

4. *Provide the option to display a more complex user interface for QoS*

There was little agreement on any of the issues discussed. Any single user interface would leave many viewers unhappy. As proposed by a number of participants during the focus-group discussion, the user interface should have basic and advanced features. As one participant point it out, "like any software program", it should be customizable and allow flexibility for users. For knowledgeable users, the interface should provide advanced options so that users can control a variety of different attributes and have their own preferences, as suggested by Bochmann and Hafid (1999). A primary requirement is that it must be easy to switch between the default simple user interface and advanced user interfaces and the advanced user interface must be easy to use. The advanced user interface would require the following features.

a. Provide multiple sliders for separate quality attributes

The advanced user interface should have separate controls for each of the 5 video streaming attributes, but the users would not have to use them if they don't want to. A few participants pointed out that one sliding bar actually limits user control. Another reason stated during the discussion was that users would like to know what they are paying for so they need to control each video quality attribute. The possibility of paying less by sacrificing one video attribute in exchange for another was also mentioned. This was actually called a trade off that the user is making in the negotiation process, as presented in Fry et al. (1997). In this study, to adjust and control the QoS, the users could specify that maintaining a high frame rate is more important than the image size. With multiple sliders, users can weight the QoS video streaming attributes by sacrificing one attribute that's not important in favour of another one that they need.

b. An option should be provided to replace continuous sliders with discrete buttons

Viewers should be allowed to set a preference for continuous sliders or for discrete levels of control. One way to achieve this is to replace the sliders with three levels of controls— low, moderate and high quality – but any number of discrete values would be possible.

c. There should be an option to preview video quality

After adjusting the quality using sliding bars, users should be able to preview the video quality obtained. Users would like to compare the current quality with the higher quality. The video previews could be located above the sliding bars and presented as short video clip of the quality obtained. The technical difficulties of providing this feature

are unknown, but it is desirable for users. As a solution, Bochmann and Hafid (1999) suggested presenting a variety of possible quality examples that the system is capable of offering, described as combinations of video streaming attributes. Then users decide which combination is the most appropriate for the situation and cost. A large number of possible combinations might not be possible because there is a risk of complicating the user interface and confusing users.

d. Cost of quality should be previewed

Users should be able not only to see a preview of the video quality obtained but also a preview of the price they would pay. A few participants suggested a price preview so that if the cost were too high, then the quality could be re-adjusted. Some users would like to avoid paying more than they are willing to spend. They also expressed their wish to be able to play with the user interface and set the quality at the maximum to see the price and then to compare the quality and the price with a lower quality.

e. Dynamic feedback should be provided as it is adjusted

If technically possible, a few users wanted to see the effect of any adjustment as they are making changes. One participant compared the dynamic control and immediate feedback to the adjustment of the brightness of the monitor where the result of the manipulation is apparent as it happens. Other research has also shown that users expect to see the effects of their changes immediately (Banks and Rowe, 1997).

f. Preset quality combinations should be available by clicking buttons

Buttons should be available for a number of common types of video content for different quality combinations. A few users would like to click on preset buttons rather than moving a sliding bar. For example, there might be buttons for sporting events,

movies, concerts, news, etc. For a sporting event, the button should provide QoS that emphasizes frame rate or the audio/video synchronization and for movie, the button should emphasize the image size, the frame rate or the audio/video synchronization. Also, streaming media companies could suggest options for obtaining the appropriate video quality for different type of video content. Users who are not knowledgeable would choose what was suggested. In one research study it was recommended that the system should display examples of different quality such as video with different colors and resolution or, related audio and video with different synchronization qualities to allow users to select among the examples (Bochmann et al, 1998).

g. Users should be able to define, save and reuse quality settings

Once users have set the quality they want, they should be able to save their own combinations as presets and assign meaningful labels to them for later use. For example, they might find a combination of settings that they really like for movies so those settings could be stored and later called up for any movie without adjusting sliders each time.

h. Pay per view fee structure should be provided

Users should have more payment plans than just the monthly payment method. This plan can include an enhanced quality fee for weeks, months or years or they could opt for a pay per view payment scheme. One study (Cosgrove and Lidhard, 1979, as cited by Bouch and Sasse, 2001) suggested that users prefer a flat-fee price, where they have limited control over the QoS they received, than a price based on their usage of streaming media. Another recommendation that was mentioned in the discussion would be that users should get a single bill, either from the Internet Service Provider or the websites that are providing the content, but not both.

Focus-group Methodological Issues

One of the objectives of this thesis was to study two focus-group methodological issues: the impact on ratings and comments of examples of video quality and the impact of examples of the user interface. Mayhew (1999) recommends conducting focus groups with a mock-up or a simulated product to stimulate users' memories. Without using any cue, users are likely to have trouble thinking about and describing the issues. Mayhew (1999) also warned that the use of a concrete example might constrain participants to the specific example illustrated. To address these concerns, two types of video quality examples, a visual demonstration and a verbal description, were presented to help participants understand what QoS is. The purpose of this manipulation was to see if the visual demonstration influenced users to say different things and to rate their user attitudes toward QoS differently than users who received a verbal description of QoS. It was expected that viewers of concrete visual examples of quality differences would understand the importance of controlling QoS better than participants who received the verbal descriptions of quality differences. Also, two versions of possible user interfaces, simple and complex, were presented. The concern was that the complexity of the user interface illustrated in the focus group might have an impact on comments about and ratings of QoS. Specifically, I was concerned that a complex user interface might dissuade users from controlling QoS.

Impact of quality examples

The use of different video quality examples had no clear effect on participants' ratings on QoS issues. Although participants' ratings didn't depend on the quality example, the use of quality examples during the focus-group discussions helped

participants discuss quality and provide suggestions about the user interface for controlling QoS. For example, before the quality examples were presented, most participants were unsure about quality and not willing to participate in the discussion. Participants became more engaged in the discussion and more willing to share insights and suggestions after the presentation of video quality examples, either through visual demonstration or verbal description. In addition, much of the early discussion revolved around the cost of additional quality rather than around the need for controlling quality. Only when the video quality examples were introduced during the discussion did participants understand the issues with controlling QoS and become more willing to provide insights regarding quality and the method of controlling it. These participant comments and suggestions were useful in formulating the recommendations, presented above, for designing the user interface.

Users attitudes towards QoS were obtained twice: before a user interface example was presented and after the user interface example was presented. The nature of the user interface, simple or complex, did not have a clear impact on ratings of QoS. Ratings were similar whether a simple or complex user interface was presented.

The interaction between the video quality examples (visual or descriptive) and the user interface examples (simple or complex) was significant but none of the multiple comparisons were significant. It was believed that participants second round of ratings would depend on participants understanding of how they might control the QoS. It was also expected that the user interface example, either simple or complex, would have an effect on participants' ratings. It was difficult to draw a conclusion from the analysis of

comments during the discussion about why participants' rating generally didn't change after experiencing the user interface examples.

A second interaction involving the user interface examples was also difficult to understand. The interaction between the video quality examples used, visual demonstration versus verbal description, and the order of obtaining user ratings, before the user interface example was presented and after user interface example was presented, shown in Figure 8, was significant. Participants who saw a visual demonstration of QoS issues rated their attitudes towards QoS higher before they saw the user interface example than after they saw the user interface example. This was true for simple and complex user interface examples. Comments made by participants didn't offer a clear picture of their reasons for rating their attitudes towards QoS lower after they saw an example of a user interface or why this decrease in rating failed to occur with a verbal description of quality. The reduction in ratings when video demonstrations were used was relatively small. These results suggest that the presentation of user interface examples didn't change participants' evaluation of QoS and the nature of the user interface example in the focus group did not matter.

In any focus group, there is a concern that, the specific examples presented to participants might have an impact on their opinions and be reflected in their comments and ratings. The task of finding examples that are clear enough to illustrate the issues of concern, but not so specific that they cause participants to focus on details of the specific examples rather than the concept illustrated in the examples is a major concern in any focus group. The challenge is to get something that is the appropriate compromise

between too concrete and too abstract. In this study, the selection of specific examples to be used did not seem to be as important as expected.

It was expected that showing concrete examples of quality or telling participants about quality (more abstract concepts) would have an impact in their opinions about controlling QoS. Similarly, I was concerned that the specific user interface presented as an example of how you might control QoS would have an influence on the willingness and importance of controlling QoS. Contrary to this, whether participants viewed, the video quality example or listened to the verbal description, didn't matter. Also the simple or complex user interface didn't have any effect on participants' ratings. These results suggest that, when conducting any focus group, how you show or tell examples might not be as important as one might expect.

Although I did not find that the examples I used influenced the results obtained, any researcher using a focus group should approach the problem of choice of examples with caution. It would be premature to generalize from this study that choice of a visual demonstration or a verbal description didn't matter for participants' understanding and later for their evaluation.

Additional Focus-group Methodological Issues

A number of unexpected examples of the importance of providing specific context for the discussion were observed. Although an amount for the pay for view fee for additional quality was, by design, not mentioned by the focus-group moderator, participants in all groups spontaneously made up amounts. While the only price suggested by participants for the low standard monthly fee was \$20, the additional price

range for the “pay per view” for streaming media had a lot of variability. Suggestions for “pay per view” fee were “a few cents per minute”, “\$1 for the frame rate”, “\$2 for resolution”, “\$3 for clicking a few buttons”, “\$3 for the whole view”, “\$5 dollars for two hours” or “\$10 for a sporting event.” While some participants saw the fee per use method as a way of saving money by adding “a few bucks” to the standard monthly ISP fee, other participants saw the risk of ending up paying more at the end of the month. One can only wonder what ratings for controlling and paying for QoS would be if the moderator had used specific values for fees.

The concept of pay per view also unexpectedly dominated the early discussion in another way. When the idea of paying for better quality was first introduced, at least one participant in each focus group tried to reject the idea. Participants somehow felt that the purpose of the discussion about paying for quality was to promote a new type of payment. This topic, which was not anticipated by the moderator and, therefore, not addressed, hindered discussion of the topics that were of concern.

By design, considerable time was dedicated at the beginning of each focus-group discussion to explaining and clarifying the differences between streaming media and the download and play method. Although the requirement for participation in the focus groups clearly stated that participants should be familiar with streaming content, most of them were confused and considered downloading and playing files the same as streaming media. This was clear from the examples provided before streaming media terminology was explained. The number of downloading examples was higher than the number of streaming media examples. It is obvious from these examples that participants were experienced much more with downloading content than streaming media content. These

results emphasize the importance in focus groups of making sure that concepts and terminology are carefully explained.

It was noticed that if the topic is not known, then participants provided known concrete examples or analogies to try to understand, as mentioned by Bouch and Sasse (2000). To understand the idea of paying for the quality that is used, participants used the analogy of paying for minutes talking on cell phone and paying per view for television movies. In some respects, these analogies helped group members understand the concept, but the analogies also brought with them biases and opinions based on a different situation.

Future Research

As would be expected with focus groups, the results from this study should not be considered definitive. It is certain that the diversity of opinions implies the necessity of providing an easily tailorable user interfaces to control QoS. But issues, other than providing options for the user interface, need more study. Further research should supplement the focus-group data from this study with other user needs assessment methods. To broaden the investigation of user opinions, a user needs analysis with different types of users is recommended. It is not clear what results would be obtained with a non-student sample. Future research should use a larger variety of video clips to illustrate different quality attributes in a variety of situations such as news, sporting events, movies, etc.

To learn more about user interface requirements, future studies could evaluate specific user interfaces. Other studies could address payment schedules and the prices people are willing to pay.

Conclusion

There were a few things that worked well during the focus-group discussion. The time allocated to explain the terminology was well spent since most of the participants were not familiar with the technical terms. Engaging participants with real life situations and with examples helped them to understand the issues so they could be more involved.

There were also things that could be done differently. One thing might be to provide a larger variety of simulated video streams that illustrated different types of QoS issues to help them understand the real issues. Another thing that didn't work as expected was the fact that some participants didn't understand the distinction between the importance of having an attribute (e.g., color), the importance of controlling the attribute and the way that you control the attribute. This might have caused confusion about exactly what they were rating.

It is also possible that participants didn't understand the purpose of the second set of ratings, after presenting the user interface example and that this lack of information could have had influenced the ratings. The impact of the second ratings on demand characteristics is unclear. Some participants might have felt some pressure to give ratings that were consistent with those given the first time, while others might have interpreted the second set of ratings as an indication that they should give different ratings.

One advantage of focus groups as a method of gathering user needs is that participants provide details and ideas initially not planned to be discussed. A possible disadvantage of this approach is that the focus group may not be an efficient way to focus participants on a specific topic. For example, instead of talking about the user interface for controlling QoS after the QoS example was presented, participants spent time talking about things that were not planned or not related to the topic such as prices and payment. The moderator had to bring them back on track.

The focus groups used in this analysis, as a qualitative method, were appropriate for user needs analysis. Participants provided many opinions and suggestions of value for the design of a QoS user interface. The most important thing that was learned was that there was little agreement on most issues and any successful interface must take into account this diversity.

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Appendix A

Announcement for Recruiting

Your participation would be appreciated for a focus group that is being conducted by a Master's student from the Human Oriented Technology Lab at Carleton University. We are interested in people who have looked at video/audio over the Internet on a computer.

The purpose of the study is to gather users' views and opinions about streaming media over the Internet, controlling the quality of streaming media and willingness to pay for obtaining a better quality.

Participants recruited for the focus groups will be presented some video examples, will be asked to share their thoughts in a focus-group discussion and to fill out a questionnaire. The focus-group discussions will be video and audio taped. The discussion will last one hour and a half.

Students enrolled in the 49.101/102 will receive an experimental credit. Other students will receive \$15.

If you are interested please contact Adina Manoli at adinam@sympatico.ca or call her at (613) 520-2600 ext. 6628 to schedule a time for a focus-group session.

Appendix B

Video Clips Screen Captures

Movie file:

Hip-hop file:

Kids running file:

Appendix C

Moderator Guide

Introduction

Hello, and welcome to our focus-group session. Thank you for taking the time to join our discussion of Internet streaming media. My name is Adina Manoli. I will be the moderator for this focus group. The focus group is part of my masters' thesis research.

Before presenting the focus-group ground rules, I would like you to read and sign the Informed Consent Form. *(The Informed Consent Form is shown in Appendix G).*

(Give participants the forms).

(Wait until participants fill out the questionnaire.)

Now I will give you a background questionnaire about you as an Internet user. *(The Background Questionnaire can be found in Appendix E).*

(Give them the questionnaire).

(Wait until participants fill out the questionnaire.)

Present Focus-Group Ground Rules

Before starting the discussions, let me suggest some things that will make our discussion more productive. Please speak up only one person should talk at a time. We are audio and video taping the session because we don't want to miss your comments. We've placed name cards on the table in front of you to help us remember each other's names. We'll be on a first name basis, and in our later reports there will not be any names attached to the comments that you are making. You are assured of confidentiality.

My role here is to ask questions and listen. I want you to feel free to talk with one another. In these discussions, some people might talk a lot and some people might not say much. It is important for us to hear from each of you because you have different experiences. So, if one of you is sharing a lot, I might ask you to let others talk. And if you aren't saying much, I may ask you for your opinion.

Participants Introduction

Let's begin. Let's find out some more about each other by going around the table. Please tell us your name and describe in a few words your Internet use, such as type of Internet connection and what you use the Internet for.

(Wait until all participants introduced themselves).

We would like to hear today how Internet users feel and think about the use of streaming media on the Web. *(Give participants a short definition.)*

With video streaming, the video files can be played as they are downloaded on the computer. The media is sent in a continuous stream and is played as it arrives, eliminating the necessity to completely download the file before playing.

We invited people who are Internet users to share their thoughts, feelings and ideas about this. You were selected because you are all Internet users. During the discussion, you'll tell us your opinions. We would like to find out what are your needs and wants when you use streaming media. There are no wrong answers but rather differing points of view. We are interested in what's good and bad about streaming media, your opinions, impressions and criticisms. Please feel free to share your point of view even it differs from what others may say.

Step one: Participants shared examples

I would like you to give me some examples of streaming media. Please share your examples from your own experience.

(Make sure that participants understand the difference between the "download and play" and streaming video.)

(Write the examples on the flip chart. Make two separate lists of streaming media and download and play characteristics. Also write down some of their examples that are relevant to understanding the concepts and the differences between streaming and downloading.)

Step two: Differences between streaming media and downloading

(If participants don't know what streaming media is, then explain and point out the difference between streaming versus downloading.)

(Below is the type of information that needs to be clarified/understood before starting the discussion about controlling and paying.)

With "download and play", method the entire video file is downloaded over a network to a file and store to the hard drive. The advantage of this method is that high quality video can be delivered. The disadvantage is that the user must wait for a long time for the download to complete and needs disk storage space available for the download to complete.

With video streaming, the files can be played as they are downloaded to the client, thus a web user does not have to download a large file before seeing the video and hearing the sound. To see the video, the user needs a video player, which can be an integral part of the browser or it can be downloaded from the web. The advantage is that the file can be played sooner, not occupying as much disk space,

and minimizing the copyright concerns. The disadvantage is that the quality of video can be poor due to network congestion and delays.

Step three: More examples of streaming media

(Ask participants to say more/give more examples before discussion to ensure they understood the difference between these two concepts before the discussion about controlling and paying more.)

I would like you to give me more examples of streaming media. Think about problems that you have when watching streaming media.

(Write/ emphasize participants' examples on the flip chart.)

(Write down any good points and probe the bad things/ problems.)

Step four: Use examples to discuss video characteristics.

(Use participants' examples to discuss the following video streaming attributes: frame rate, synchronization between video and audio, resolution, image size and color. The streaming video attributes might not be discussed in the same order.)

1. Frame rate:

What do you think frame rate is?

(If participants don't know what frame rate is, provide the definition: the number of still pictures displayed per second to give the perception of motion.)

Questions:

When do you need frame rate?

Can you think of an example when you don't need frame rate?

2. Resolution:

What do you think resolution is?

(If participants don't know what resolution is, provide a short explanation: resolution refers to sharpness and clarity of the image.)

Questions:

When do you need a higher resolution?

Can you think of an example when you might need resolution?

3. Image size:

What do you think image size is?

(If participants don't know what image size is, provide a short explanation: image size refers to the number of pixels contained.)

Questions:

Can you think of an example when you might need to adjust the image size?

4. Synchronization of audio/video:

What do you think audio/video synchronization is?

(If participants don't know what audio/video synchronization is, provide a short explanation: audio/video synchronization is the extent to which sounds and movements occur together, e.g. lips move at the same time as people speak.)

Questions:

When do you need good audio/video synchronization?

Can you think of an example when you might need or you might not need better audio/video synchronization?

5. Color:

(If participants don't know what color is, provide a short explanation: color quality represents the number of different colors you can see.)

Questions:

Can you think of an example when you might need more colors?

(Use participants' examples to emphasize the need of paying more for better quality :)

If you have a bad quality you are not going to see every frame, it's not very smooth; or if you have a low resolution you not see every movement. To see every movement or to have better audio/video synchronization, you need to pay more.

Step five: Introduce controlling and paying for quality

(Present and write down on the flip chart three methods of payment.)

Now I would like to give you three possible methods of payment:

1. You can pay a low monthly standard fee for Internet connection. This option is good for web surfing and e-mail but not good for watching streaming video and audio.

2. You can pay a monthly higher fee for high speed for Internet connection. This option is much better for streaming media but the quality is not guaranteed.
3. Or you can choose a standard fee + pay more any time when you want to watch streaming media. This third option is called “pay per view” and it gives you the possibility of having higher quality and the dynamic control the video streaming attributes like: higher frame rates, more resolution, larger image size, more synchronization of video and audio and more colors.

Why “pay per view”?

- You pay more and you get the priority over other users
- This gives you a better quality
- You can get this quality with ADSL/cable
- You can have controls that help you to get the quality desired for a specific video content that you’d like to watch

(Emphasize the fact that if they choose the “pay per view” method, they might be able to control the quality but they don’t have to do it all the time.)

Step six: Discussion about “pay per view”

(All participants are invited to share their point of views about the “pay per view” method.)

Please tell us what do you think about the third method of payment, the “pay per view” method, and what do you think about controlling video characteristics and paying more for better quality.

Step seven: Visual or Verbal presentation of Video Quality Examples

Visual Demonstration of Video Quality Examples

We know that currently we don’t have any dynamic control over the quality of the streaming media. Now, I would like to show you some examples. By showing you these video files you’ll see the difference between high and low quality video. With more or less frame rates and more or less video compression rates. *(Show them examples while explaining.)*

First example: hip hop- high quality, then low quality.

Second example: Fraser- high quality, then low quality.

Third example: Running- high quality, then low quality.

These settings have a cost. For higher video quality, you pay more.

Verbal Description of Video Quality Examples

We know that right now we don't have any dynamic control over the quality of the streaming media. Now, I would like you to think about an example. In general, there are some noticeable differences between a higher and a lower quality. This is because there are different settings for compression and frame rate. For example, if you choose a higher frame rate you will get a better quality; you will see every movement, and smoothness of the video. If you choose a lower frame rate you will have a lower quality with blocks and not always smooth. This difference can be also noticeable when you watch different types of streaming video. For a slow action video content, such as a movie, you might not want to have a high video quality. For lot of action, such as dancing or running - you might want a higher video quality. Note that the more video quality attributes you want the better the quality is. Also, if you'd like to have a higher video quality, you pay more.

Step eight: Discussion

Let participants talk and share their opinions and answer to the questions.

If they don't raise the issues of controlling and paying more to achieve the quality, then have prepared the following:

- a) Would you like to be able to control video quality settings?
- b) Would you pay more to obtain a better quality? Would you be willing to pay more?

Step nine: First set of rating scales

I would like to find out your opinion on what type of video characteristics you would consider important to control when watching streaming media and what you are willing to control and pay more to achieve a better quality. Listed on this paper are five video attributes with a short definition and the rating scales.

Please do the rating by placing a mark on the horizontal line. You have a few minutes to complete this.

(Participants will receive the rating scales. The rating scales are shown in Appendix F. The example on how to do the ratings will be read and presented before starting the ratings.

After finishing the ratings, let participants talk and see if they have any comments after ratings.)

Step ten: Presenting the User Interface Example

Visual Demonstration of a Complex User Interface Example

(The User Interface examples are shown in Appendix D.)

To adjust these video characteristics you need a way to control the quality. This is just an example of how you might control the quality (show them a picture of a complex UI). This will help you to choose the quality desired for the specific streaming media content. The sliding bars will help you to adjust the quality desired for each video attribute (color quality, image size, frame rate, audio/video synchronization and resolution), from a lower quality to a higher quality and then pay more for obtaining this quality.

Visual Demonstration of a Simple User Interface Example

(The User Interface examples are shown in Appendix D.)

To adjust these video characteristics you need a way to control the quality. This is an example of how you might control the quality (show them a picture of a simple UI). This will help you to choose the quality desired for the specific streaming media content. The sliding bar will help you to adjust the quality from low to high. You don't need to care about the video characteristics previously discussed, resolution, frame rate, color, audio/video synchronization, and image size. The software might decide which combination is the best for a specific video content.

Verbal Description of a Complex User Interface Example

To adjust the video streaming attributes you need a way to control the quality. I would like you to think about the following example as a way of controlling the video quality: sliding bars that have two settings at each end. On the left, there is the "worse" setting option for the least price. On the right side of the sliding bar, there is the "better" option for the maximum price. You can control the quality by moving the sliding from worse to better or vice versa. You will have sliding bars for each video characteristic that we already talked about: color quality, image size, frame rate, audio/video synchronization and resolution, and you can control the quality from a lower quality to a higher quality and then pay more for obtaining this quality.

Verbal Description of a Simple User Interface Example

To adjust the video streaming attributes you need a way to control the quality. I would like you to think about the following example as a way of controlling the video quality: one sliding bar that has two settings at each end. On the left, there is the "worse" setting option for the least price. On the right side of the sliding bar, there is the "better" option for the maximum price. You can control the quality by moving the sliding from worse to better or vice versa. You don't need to care about the video characteristics previously discussed, resolution, frame rate, color, audio/video synchronization, and image size. The software might decide which combination is the best for a specific video content.

Step eleven: Discussion

Let participants talk and share their opinions after presenting the UI example.

The following questions will be prepared in case participants will not comment on the following issues: controlling video characteristics and willingness to pay.

- a) What do you think about being able to dynamically control the video quality using this way?
- b) Do you want to pay more for a better quality?

Step twelve: Second set of rating scales

Participants will receive again the rating scales. They will be asked to do ratings after seeing the simple User Interface example. The rating scales are shown in Appendix F.

After seeing the example of how you might control quality of streaming media, I would like you to do the ratings again.

Ending questions:

At the end of our discussion, I would like to know if you want to add other things or if there are other issues that we've missed.

(Thank participants for their contribution, give them the debriefing form and pay for participation.)

(The Debriefing Form is shown in Appendix H.)

Appendix D

User Interface Examples

Simple User Interface Example:

Complex User Interface Example:

Color		
Worse \$		Better \$
Frame rate		
Worse \$		Better \$
Image size		
Worse \$		Better \$
A/V Synchronization		
Worse \$		Better \$
Resolution		
Worse \$		Better \$

Appendix E

Background Questionnaire

Web and Streaming Media Experience Questionnaire

For the following questions, please circle the single alternative that describes you:

1. How often do you access the Internet?

- a) Daily
- b) 4-6 times per week
- c) 2-3 times per week
- d) Once per week
- e) Less than once per week

2. What type of Internet connection do you use at home?

- a) DSL
- b) Cable
- c) Telephone dial-up
- d) Other, please specify _____
- e) Don't know

3. Do you listen to audio or view videos over the Internet?

- a) Yes
- b) No (Go to question 6)

4. What type of video content do you watch? (Circle all that apply)

- a) News
- b) Movies
- c) Music
- d) Sporting events
- e) Other (please specify) _____

5. What type of player for watching streaming media do you use?

- a) Real Player
- b) Windows Media Player?
- c) Quick Time
- d) Other (please specify) _____
- e) Don't know

6. Check all things you use the Internet for:

- ☐ Information
- ☐ Education
- ☐ Entertainment
- ☐ Stocks
- ☐ Purchasing on-line
- ☐ Others (please specify) _____

Appendix F

Rating Scale

Importance of Controlling QoS Video Parameters and Willingness to Control and Pay for QoS Video Parameters

Listed below are characteristics for quality when watching streaming video. Please rate your willingness to control the following video quality parameters, the importance of controlling these parameters and your willingness to pay more to achieve a better quality by placing a mark on the horizontal line.

Here is an example illustrating how to use the rating scale.

How important is it to customize the toolbar?

The example above illustrates that it is relatively important to customize the toolbar.

1. Color quality is the number of different colors you can see.

How important is to have different numbers of colors at different times?

How willing are you to control the number of colors?

How willing are you to pay more for more colors?

2. Frame rate is the number of still pictures displayed per second to give the perception of motion.

How important is it to have different frame rates?

How willing are you to control the frame rate?

How willing are you to pay more for higher frame rates?

3. Image size refers to the number of pixels contained in each frame, e.g., 800 by 600.

How important is it to have different image sizes?

How willing are you to control image size?

How willing are you to pay more for better larger images?

4. Synchronization of video and audio is the extent to which sounds and movements occur together, e.g., lips move at the same time as people speak.

How important is it to have audio and video synchronization?

How willing are you to control the degree of synchronization of audio and video?

How willing are you to pay more for better audio and video synchronization?

5. Resolution refers to sharpness and clarity of the image.

How important is it to have video resolution?

How willing are you to control the video resolution?

How willing are you to pay more for video resolution?

Appendix G

Informed Consent Form

An Informed Consent Form is required by the Ethics Committee of the Psychology Department for research projects conducted by students enrolled in psychology courses, and by department faculty members. The purpose of an informed consent is to ensure that you understand the purpose of the study and the nature of your involvement. The informed consent must provide sufficient information such that you have the opportunity to determine whether you wish to participate in the study.

Present Study: A User Needs Analysis for Negotiating the Quality of Service for Streaming Media Applications

Research Personnel: The following people are involved in this research project and may be contacted at any time. The principal investigator is Adina Manoli, Master's student, Carleton University, phone (613) 520-2600 ext. 6628. The principal faculty advisor of this project is Dr. Richard Dillon, Psychology Department, Carleton University, phone 520-6629. If you have any ethical concerns about this study please contact Professor Mary Gick, Chair of Carleton University Research Ethics Committee for Psychological Research, Department of Psychology, Carleton University, phone (613) 520-2600 ext. 2664. Should you have any other concerns about this study please contact Professor Kim Matheson, Chair of the Psychology Department, Carleton University, phone (613) 520-2600 ext. 2648.

Purpose: The purpose of this study is to gather user needs information about controlling quality of streaming media applications.

Task requirements: You will participate in a focus group with other Internet users. At the beginning of the focus group you'll be asked to fill out a short background questionnaire about Internet use. You'll be asked to share your opinions and thoughts about controlling the quality when using streaming media applications over the Internet. The focus-group discussion will be video and audio taped. During the discussion you'll be asked to fill out a questionnaire with rating scales about the importance of controlling streaming media and your willingness to control streaming media.

Duration and Locale: The focus-group session will last approximately one and a half hour. The focus groups will take place in Room 210 Social Science Research Building at Carleton University.

Anonymity/Confidentiality: The data collected in this research study is confidential. All the data is collected such that your name is not associated with the data. The data will only be made available to the researchers associated with this project. The focus-group discussion will be video and audio recorded. The video and audio recordings will be destroyed at the end of this study.

Potential risk of discomfort: There are no potential physical and psychological risks in this study.

Right to withdraw: You have the right to withdraw from the experiment at any time without compensation penalty.

I have read the above description of the Focus-group discussion about streaming media applications and I understand the conditions of my participation. My signature indicates that I agree to participate in this experiment.

Participant's Name: _____

Participant's Signature: _____

Researcher's Name: Adina Manoli

Researcher's Signature: _____

Appendix H

Debriefing Form

Because of the increase of bandwidth and streaming technologies, video on the Web is becoming popular. Streaming technologies still face many problems. Network delay and congestion can lead to poor video quality and frustration. Researchers are investigating the possibility of letting users control the quality they demand. You would be able to pay for better quality of streaming media when you need it and save money with poorer quality when quality doesn't matter using some sort of user interface right on the computer. The purpose of this study is to gather user requirements in focus groups to help us to design a user interface that would allow people to effectively control the quality of streaming media. We are interested in your opinions and thoughts about controlling quality and your willingness to pay more to achieve a better quality.

To get your comments on these issues, you were provided with a few video examples (or verbal description) and a user interface example to help you to understand the current problems and give you the opportunity to share your comments and rate your preferences for controlling quality and for importance of controlling it.

Thank you very much for participating in the study. If you have any questions or comments about this study, please contact the principal investigator, Adina Manoli, Master's student, phone (613) 520-2600 ext. 6628. The principal faculty supervisor of this project is Professor Richard Dillon, Psychology Department, Carleton University, phone (613) 520-6629. If you have any ethical concerns about this study, please contact Professor Mary Gick, Chair of the Carleton University Research Ethics Committee for Psychology Research, Department of Psychology, Carleton University, phone (613) 520-2600 ext. 2664. Should you have any other concerns about this study please contact Professor Kim Matheson, Chair of the Psychology Department, phone 520-2600 ext. 2648.

Appendix I

Analysis of Variance for Mixed Factorial Design

Source	SS	df	MS	F
Between subjects				
Video quality example	1.30	1	1.30	0.00
User interface example	69.64	1	69.64	0.06
Video quality example X User interface example	11942.46	1	11942.46	10.24*
S within-group error	4663.64	4	(1165.91)	
Within subjects				
Order of ratings	520.82	1	520.82	2.52
Order of ratings X Video quality example	1816.37	1	1816.37	8.78*
Order of ratings X User interface example	500.69	1	500.69	2.42
Order of ratings X Video quality example X User interface example	600.24	1	600.24	2.90
Order of ratings X S within-group error	826.76	4	(206.69)	
Video attributes	11068.30	4	2767.07	15.78**
Video attributes X Video quality example	964.29	4	241.07	1.37
Video attributes X User interface example	739.35	4	184.83	1.05
Video attributes X Video quality example X User interface example	247.18	4	61.79	0.35
Video attributes X S within-group error	2805.14	16	(175.32)	
User attitudes towards QoS	29001.52	2	14500.76	28.13**
User attitudes towards QoS X Video quality example	473.52	2	236.76	0.45
User attitudes towards QoS X User interface example	541.58	2	270.79	0.52
User attitudes towards QoS X Video quality example X User interface example	2826.84	2	1413.42	2.74
User attitudes towards QoS X S within-group error	4122.58	8	(515.32)	
Order of ratings X Video attributes	475.24	4	118.81	2.35

Table Continues

Order of ratings X Video attributes X Video quality example	88.80	4	22.22	0.44
Order of ratings X Video attributes X User interface example	705.85	4	176.46	3.50*
Order of ratings X Video attributes X Video quality examples X User interface example	151.80	4	37.95	0.75
Order of ratings X Video attributes X S within-group error	806.18	16	(50.38)	
Video attributes X User attitudes towards QoS	2442.02	8	305.25	9.53**
Video attributes X User attitudes towards QoS X Video quality example	585.49	8	73.28	2.28*
Video attributes X User attitudes towards QoS X User interface example	232.25	8	29.03	0.91
Video attributes X User attitudes towards QoS X Video quality example X User interface example	332.72	8	41.59	1.29
Video attributes X User attitudes towards QoS X S within-group error	1024.67	32	(32.02)	
Order of ratings X User attitudes towards QoS	72.01	2	36.00	0.37
Order of ratings X User attitudes towards QoS X Video quality example	932.77	2	466.30	4.83*
Order of ratings X User attitudes towards QoS X User interface example	479.02	2	239.51	2.48
Order of ratings X User attitudes towards QoS X Video quality example X User interface example	211.86	2	105.93	1.09
Order of ratings X User attitudes towards QoS X S within-group error	772.46	8	(96.55)	
Order of ratings X Video attributes X User attitudes towards QoS	470.99	8	58.87	1.95
Order of ratings X Video attributes X User attitudes towards QoS X Video quality example	316.04	8	39.50	1.31
Order of ratings X Video attributes X User attitudes towards QoS X User interface example	97.43	8	12.18	0.40
Order of ratings X Video attributes X User attitudes towards QoS X Video quality example X User interface example	385.25	8	48.15	1.60
Order of ratings X Video attributes X User attitudes towards QoS X S within-group error	962.03	32	(30.06)	
Total	852777.12	239	356.80	

Note. Values enclosed in parentheses represent mean squares errors; * $p < .05$, ** $p < .01$

Appendix J

Interaction between Video Streaming Attributes, User Interface Examples and Order of Ratings

The 3-way interaction between video streaming attributes (color, frame rate, image size, audio/video synchronization, resolution), user interface examples (simple or complex) and order of ratings (before user interface examples and after user interface examples) was significant, $F_{(4, 16)} = 3.50$, $p < .05$. This interaction was not interpretable.

In both graphs, as shown in Figure 1, the vertical axis is the rating scale. Both graphs show the interaction between video streaming attributes (on the horizontal axis) and the type of user interface example (squares for simple user interface example and circles for complex user interface example). The graph on the left shows this interaction before the user interface was shown and the graph on the right shows it after the user interface was shown.

Figure 1: Interaction between streaming media attributes (color, frame rate, image size, audio/video synchronization, resolution), user interface examples and (simple or complex) and order of ratings (before user interface examples, on the left and after user interface, examples on the right).

Appendix K

Interaction between Order of Ratings, User Attitudes Towards QoS and Video Quality Examples

The 3-way interaction between order of ratings (before user-interface examples and after user-interface examples), user attitudes towards QoS (importance of controlling QoS, willingness to control QoS and willingness to pay QoS) and video quality examples (visual demonstration and verbal description) was significant, $F_{(2,8)} = 4.83, p < .05$. This interaction was not interpretable.

In both graphs, as shown in Figure 2, the vertical axis is the rating scale. Both graphs show the interaction between the order of getting ratings (on the horizontal axis) and the user attitudes towards QoS (squares for important to control, circles for willingness to control and triangles for willingness to pay). The graph on the left shows this interaction for visual demonstration condition and the graph on the right shows it for the verbal description condition.

Figure 2: Interaction between order of ratings (before user-interface examples and after user-interface examples), user attitudes towards QoS (importance of controlling QoS, willingness to control QoS and willingness to pay QoS) and video quality examples (visual demonstration, on the left and verbal description, on the right).

Appendix L

Interaction between Video Streaming Attributes, User Attitudes towards QoS and Video Quality Examples

The 3-way interaction between video streaming attributes (color, frame rate, image size, audio/video synchronization, resolution), user attitudes towards QoS (importance of controlling QoS, willingness to control QoS and willingness to pay QoS) and video quality examples (visual demonstration and verbal description) was significant, $F_{(8,32)} = 2.28, p < .05$. This interaction was not interpretable.

In both graphs, as shown in Figure 3, the vertical axis is the rating scale. Both graphs show the interaction between video streaming attributes (on the horizontal axis) and the user attitudes towards QoS (squares for important to control, circles for willingness to control and triangles for willingness to pay). The graph on the left shows this interaction for visual demonstration condition and the graph on the right shows it for the verbal description condition.

Figure 3: Interaction between video streaming attributes (color, frame rate, image size, audio/video synchronization, and resolution), user attitudes towards QoS (importance of controlling QoS, willingness to control QoS and willingness to pay QoS) and video quality examples (visual demonstration, on the left and verbal description, on the right).

Appendix M

Summary of Participants' Specific Comments

Participants' examples of streaming media and downloading

Table 1

Examples of downloading before and after explanation

Downloading examples	Number of examples	
	Before explanation	After explanation
News video clips on CNN (recorded)	4	-
Movie trailers	5	4
Download music	8	-
Download movies	6	-
Kaaza (shareware program)	3	-
Video clips	5	3
News broadcast (recorded)	5	1
Sports highlights	-	1
Greeting cards	-	1
Flash intro website	-	1

Table 2

Examples of streaming media before and after moderator's explanation

Streaming media examples	Number of examples	
	Before explanation	After explanation
Web camera	3	3
TV shows	3	-
Live sports	3	1
News online	3	2
Music	-	2
Stocks online	1	-

Participants' description of streaming media

Table 3

Frequencies of terms used to describe streaming media

Terms used to describe streaming media	Frequencies of terms used
Choppy	12
Unclear/ fuzzy/ blurry	6
It starts and stops	5
Blocky	4
Paused	4
Buffered	4
Skippy	3
Slower	3
Pixelated	2
Annoying, frozen, crap, little squares, not continuous, interference	1

Appendix N

Means and Standard Errors for Ratings

Table 1

Means and standard errors for user attitudes towards QoS

	Mean	Standard error
Importance of controlling	79.46	1.30
Willingness to control	66.68	2.67
Willingness to pay	52.55	4.31

Table 2

Means and standard errors for video streaming attributes

	Mean	Standard error
Color	52.82	3.45
Frame rate	68.22	3.60
Image size	68.61	0.96
Resolution	70.37	2.82
A/V synchronization	71.14	2.19

Table 3

Means and standard errors for the interaction between user attitudes towards QoS video streaming attributes

		Mean	Standard error
Color	Importance of controlling	64.69	3.11
	Willingness to control	53.91	4.28
	Willingness to pay	39.87	5.23
Frame rate	Importance of controlling	78.64	2.75
	Willingness to control	70.67	4.23
	Willingness to pay	55.36	4.84
Image size	Importance of controlling	80.16	1.00
	Willingness to control	73.15	2.42
	Willingness to pay	52.51	2.54
Resolution	Importance of controlling	90.25	2.72
	Willingness to control	62.85	3.14
	Willingness to pay	58.01	5.23
A/V synchronization	Importance of controlling	83.58	1.34
	Willingness to control	72.84	3.28
	Willingness to pay	56.99	4.65

Table 4

Means and standard errors for the interaction between video quality examples and order of getting ratings

Video quality examples	Order of getting ratings	Mean	Standard error
Visual demonstration	Before UI example	73.75	4.40
	After UI example	58.76	4.40
Verbal description	Before UI example	59.79	4.40
	After UI example	72.82	4.40

Table 5

Means and standard errors for the interaction between video quality examples and user interface examples

Video quality examples	User interface examples	Mean	Standard error
Visual demonstration	Simple UI	70.38	3.74
	Complex	61.93	2.98
Verbal description	Simple UI	65.03	3.74
	Simple UI	67.58	2.98