

User Assessment for Negotiating the Quality of Service for Streaming Media Applications

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Abstract

The increase of bandwidth and streaming technologies has made video on the Web viable. 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) has emerged. Broadly, the notion of QoS is a reflection of user perception and determines the degree of satisfaction of a user with the video. One way to ensure that users get the QoS that they want for multimedia materials over the Internet is to give them 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. To design such a user interface, a user needs assessment was conducted to understand the user needs, problems and preferences when using and controlling streaming media applications over the Internet.

Eight focus groups were conducted and during the discussions participants received different types of information on 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 types of user interface examples for controlling QoS, one simple and one complex, were also presented during the discussion.

Results shows 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. 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.

Key words: Quality of Service, User Needs Assessment, focus groups, user interface requirements

1. Introduction

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). Recently, some researchers (Bauer & Patrick, 2002) are now calling the result of QoS as experienced by users -Quality of Experience (QoE), to emphasize the difference between the technical capabilities and the user experience. In this paper, the more

general term, QoS, which has been used for years by researchers to refer to user's experience as well as the technical capabilities, is used. Nevertheless, this paper is concerned solely with user experience, not the technology that makes such control possible.

Studies on QoS and User Interfaces for controlling QoS

Until recently, most of the research in the area of Multimedia applications and QoS was concerned with technical aspects such as algorithms, protocols or certain characteristics of network performance outside the control or influence of end-users. 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. 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 and control different levels of quality for different applications. For example, one user interface for controlling QoS, proposed by Bochmann et al. (1999), allows the user to control and modify the quality by moving sliding bars and set desired values for QoS attributes, such as audio, video, text or cost. In another example, the user interface, proposed by Antoniadis et al., (1998), has a single slider for controlling only the cost. In this case, the individual quality characteristics are completely hidden from the viewer and the quality obtained depends on how much the viewer is willing to pay.

It is still not known if viewers are able or willing to interact with the user interface, control the QoS video parameters and negotiate the price for achieving the desired quality.

2. Objectives of the Study

The first objective of this study was to gather user-needs information about streaming media and to study methodological problems in the use of focus groups for user-needs assessment.

The second objective of the study was to analyze the effect of using a visual demonstration of QoS attributes as opposed to verbal a description of the same attributes in focus groups. Participants would be asked about things they might not have experienced before such as quality of different video frames on video images, willingness to control quality, and willingness to pay for additional quality. To help participants understand and talk about QoS issues, during the focus-group discussion, they were given either a visual demonstration or a verbal description. 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. 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. These specific manipulations in this study provide insights into similar problems that might be encountered in any focus group study.

3. Method

The study was done as part of Master's thesis research. Forty-one students participated in 8 focus groups. All participants were Internet users who reported that they watched video and audio over the Internet. Four of the focus groups received a visual demonstration of QoS issues and the other four received a verbal description of QoS issues. Two focus groups out of four saw a visual demonstration of 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 QoS 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.

The demonstration consisted in a presentation of three types of video clips with a low video quality and high video quality. The low video quality had low frame rate and poor resolution, while the high video quality had higher frame rate and higher resolution. For the verbal description of the video quality, issues were described without showing any example.

A second demonstration was a presentation of two user interface examples: a simple user interface with one sliding bar for controlling the video quality and dollar signs at both ends of the bar, and 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.

3.1 Focus-group Discussion's Steps

3.1.1 The discussions started with an introduction to the streaming media topic including a definition and examples; participants were asked to provide examples from their experience to clarify the concepts of streaming media versus “downloading and playing”; the pay per view method of payment was introduced into the discussion.

3.1.2 Participants received either a visual demonstration of video quality or a verbal description of the same video quality followed by a discussion.

3.1.3 Participants were asked to rate the importance of controlling, willingness to control and willingness to pay.

3.1.4 User interface examples, either simple or complex, were shown or verbally described followed by a discussion.

3.1.5 To see if their rating would change, participants were asked again to rate the importance of controlling, willingness to control and willingness to pay.

4. Results

Quantitative analyses were conducted on participants' ratings about QoS for a number of different video streaming characteristics. Qualitative analyses were conducted on participants' comments and opinions during the focus-group discussions. Participants' comments are supporting the quantitative data and included in the discussion.

A five-way mixed factorial ANOVA was used to analyse quantitative data. 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). The three within-subjects variables were the order of ratings (ratings obtained before and after participants saw the user interface example), the five attributes to be controlled to obtain video quality (color, frame rate, image size, audio/video synchronization, and resolution) and 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.

Significant interactions were examined by performing simple main effect analyses, which were followed by multiple comparisons, using the Bonferroni correction, if the simple main effects were significant. Results that were significant are presented.

4.1 User attitudes towards QoS

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 1.

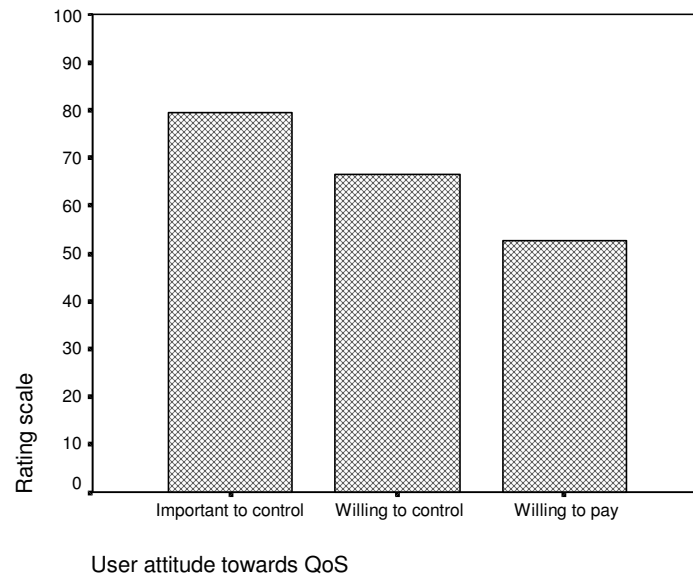


Figure 1. Mean rating for importance of controlling QoS, willingness to control QoS and willingness to pay for QoS

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.

4.2 Users attitudes towards the QoS streaming video attributes

There were significant differences in ratings for the five video attributes, shown in Figure 2, $F_{(4, 16)} = 15.78, p < .05$.

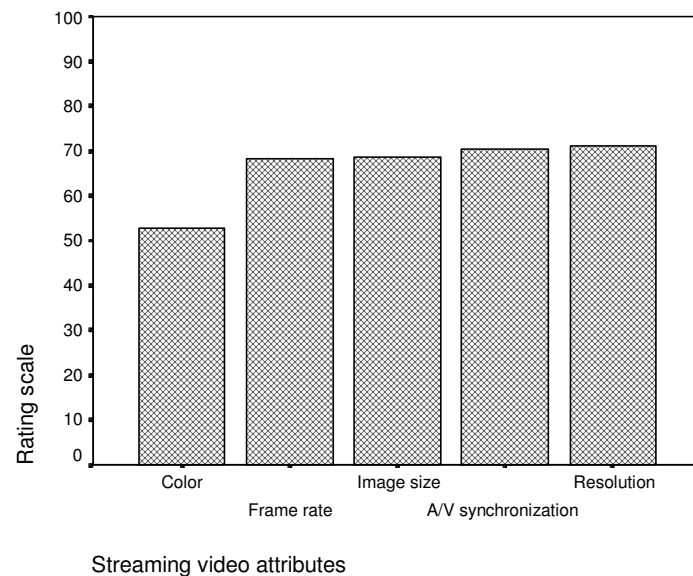


Figure 2. Mean rating for streaming video attributes

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

4.3 Interaction of video streaming 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 3, was significant, $F_{(8,32)} = 9.53$, $p < .01$

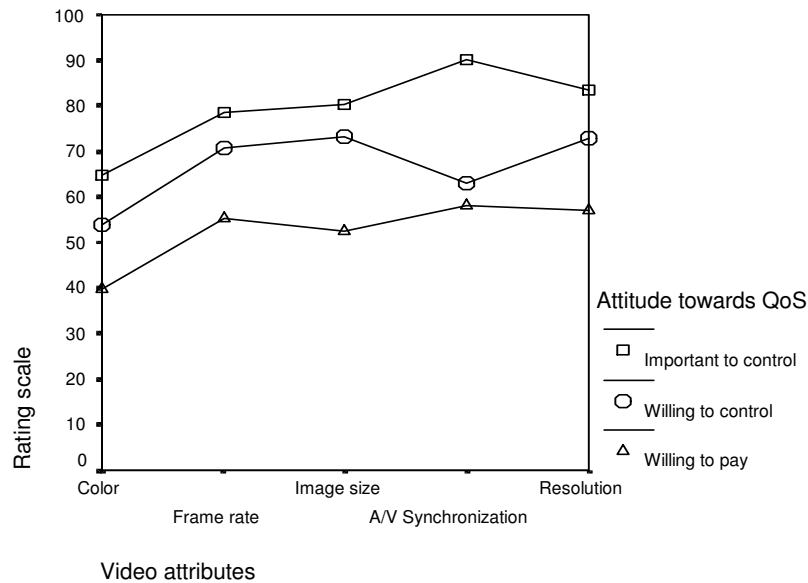


Figure 3. Interaction between video attributes and user attitudes towards QoS

A series of multiple comparisons were performed to understand the interaction. The importance of controlling was higher than the willingness to control, all $p < .001$. Also participants rated the willingness to control lower than the importance of controlling for color, and audio/video synchronization, but not for frame rate, image size and resolution, $p < .001$. Another important significance was for audio/video synchronization. This was rated higher for importance of controlling and lower for willingness to control.

4.4 Other Significant Results

The two-way interaction between the video quality example (visual demonstration versus verbal presentation) and the order of ratings (before and after presenting the user interface example) was significant, $F_{(1, 4)} = 8.78$, $p < .05$. The main effect of user interface example (simple UI versus complex UI) 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 $F_{(1, 4)} = 10.24$, $p < .05$. Both interactions were uninterruptible because of statistical inconsistencies.

5. 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.

5.1 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 (Figure 1). However, even the mean ratings for willingness to pay for quality are not excessively low. 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-groups were conducted with students and students are afraid that the cost might be too high for them.

Evaluations for frame rate, image size, resolution, and audio/visual synchronization were almost the same but color was rated lower (Figure 2). 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.

User attitudes towards controlling five streaming video attributes were evaluated in relation to user attitudes towards QoS. Although this interaction, shown in Figure 3, was significant, it appears that the interaction is primarily attributable to the ratings for audio/visual synchronization. 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. The comments did not help explain this unusual result.

5.2 Requirements for QoS Controls and the User Interface

Based on the results obtained and participants' suggestions, 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. Therefore, a simple UI was proposed by default and with an option for a more complex UI.

5.1.1 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 for people who are not knowledgeable about streaming media.

5.1.2 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.

5.1.3 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.

5.1.4 Provide the option to display a more complex user interface for QoS

There was little agreement on any of the issues discussed. Any single UI would leave many viewers unhappy. As proposed by a number of participants during the focus-group discussion, the UI should have basic and advanced; it should be customizable and allow flexibility for

users. A primary requirement is that it must be easy to switch between the default simple UI and advanced UIs. The advanced UI would require the following features:

5.1.4.1 Provide multiple sliders for separate video 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 and the users would like to know what they are paying for. With multiple sliders, users can weight the QoS attributes by sacrificing one attribute that's not important in favour of another one that they need.

5.1.4.2 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.

5.1.4.3 There should be an option to preview video quality and the cost of quality

After adjusting the quality, users should be able to preview the video quality obtained and 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. Users should be also able to preview 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.

5.1.4.4 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. The dynamic control and the immediate feedback were compared to the adjustment of the brightness of the monitor where the result of the manipulation is apparent as it happens.

5.1.4.5 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, for a sporting event, the button should provide QoS that emphasizes 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.

5.1.4.6 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.

5.1.4.7 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. Also users should get a single bill, either from the Internet Service Provider or the websites that are providing the content, but not both.

5.3 Focus-group Methodological Issues

One of the objectives of this research 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 UI. 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, there was a concern that the specific UIs 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 examples or listened to

the verbal description, didn't matter. Also the simple or complex UI 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.

Even though the examples used didn't influence 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 the choice of a visual demonstration or a verbal description didn't matter for participants' understanding and later for their evaluation.

As is typical in focus-group discussions, a number of unexpected topics were raised. For example, although an amount for the pay per view fee for additional quality was, by design, not mentioned by the focus-group moderator, participants in all groups spontaneously made up amounts. 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.

6. Conclusions

As would be expected with focus groups, the results from this study should not be considered definitive. Further research should supplement the focus-group data from this study with other user needs assessment (UNA) methods. To broaden the investigation of user opinions, a UNA with different types of users is recommended. Other studies could evaluate specific user interfaces and address payment schedules and the prices people are willing to pay.

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. As a possible disadvantage, the focus group may not be an efficient way to focus participants on a specific topic. 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 user interface issues and any successful interface must take into account this diversity.

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