

Quality of service negotiation based on device capabilities and user preferences

K. El-Khatib, X. He, G. v. Bochmann

School of Information Technology & Engineering,
University of Ottawa, Colonel By Hall
(A510) P.O. Box 450 Stn A, Ottawa, Ont., Canada
K1N 6N5
Email: {elkhatib,xhe,bochmann}@site.uottawa.ca

Abstract: Most multimedia applications require the user to select certain QoS parameters. The user is also expected to have some knowledge of the software and hardware available on the device he/she is planning to use. But as the range of hardware, software, and media types is getting wider, the need for an automated system to do the selection process is increasing. In this paper, we developed a scheme for representing and storing the user preferences in a user profile. The device capabilities and capacities are also stored in a device profile. The design of automated QoS aware applications is presented. The system merges the user and device profiles for all participants to make the selection of QoS parameters.

Keywords: QoS, User QoS, User Profile, Device Profile, User Satisfaction, Device Capabilities, User Preferences.

1 Introduction

With the bandwidth becoming so abundant at the core of the network (Gigabit Ethernet, DWDM,...), much focus in research is now shifting from managing network resources to managing end-user requirements. Powerful and diverse end-user devices are getting more and more available, and many new sophisticated multimedia services are also becoming widely available. Moreover, most of the service providers are looking into ways to provide services that are much more tailored to the demand of end-user than the old traditional services (text based). While several emerging network technologies [1,2,3] are aiming to provide different Quality of Services (QoS) at the network level, most end users have little or no knowledge of these advances, and using them is considered too technical. For most end users, the importance is to get a required quality at a specified maximum price. End-users would prefer to specify their requirements and preferences regarding the quality and pricing of a service, and their end system should find out the best offer from service providers that satisfies these requirements and preferences. The end user will specify all of his preferences in his profile, and this profile will be available later on for the system to make an automatic selection of session parameters. The users should also be able to specify what type of service they would like to have when communicating with every specific person. A QoS aware end system should select the configuration parameters for the communication session depending on the capabilities of the end user device and his preferences. This selection should cover the limitations of all participants' software and hardware components.

In this paper, we show how a QoS aware end-system makes an automated selection of the hardware and software components, media type, and configuration parameter for a teleconferencing session. This selection is based on: (a) hardware and software limitations on the used devices (b) personal perception of individual media parameters and (c) the caller and callee preferences to the choice of media types. The rest of the paper is organized as follows: in Section 2, we present a survey of related work done on device profiles and automatic QoS selection. Then, in Section 3, we talk about the problem of QoS negotiation for video telephony and conferencing and our approach to solve it. Section 4 talks about the user profile and its possible representation and storage. In Section 5, we elaborate on how the device and

user profiles can be used to make automatic QoS parameter selection. Section 6 gives an example scenario and finally, Section 7 concludes the paper.

2 Related Work

Early work in the Multiparty Multimedia Session Control (mmusic) [4] working group at the Internet Engineering Task Force (IETF) resulted in the publication of the Session Description Protocol (SDP) [5] draft. SDP, designed for the Mbone environment, and "is used to advertise multimedia conferences and communicate the conference addresses and conference tool-specific information necessary for participation.". SDP is mostly concerned with the media type and the configuration of communication channels, but it does not reflect user's preferences and device capabilities.

The CONNEG working group at IETF is currently working on defining a framework [6] for content negotiation between Internet applications and Internet resources. Part of the framework is to describe the range of media features that can be handled and processed by the sender and the receiver. In [7], the format and the registration procedure for individual media features is outlined. The group is also working on the development of a media feature matching algebra based on predicate calculus.

The World-Wide Web Consortium (W3C)[8] has recently begun to define mechanisms for describing and transmitting information (Metadata) about the capabilities and properties of resources on the World Wide Web. The Composite Capabilities/ Preference Profile (CC/PP) describes the way to represent these capabilities/properties using the Resource Description Framework (RDF). The metadata for a document on the Internet could be the author of the document, its language, its content type and its creation date. A profile for a device connected to the Internet may cover the hardware platform (CPU model, the size of the memory, microphone, speaker, camera, ..), system software (operating system, list of audio and video encoders,...) and applications (JMF, Vic, Vat, whiteboard,...) available on the device. Figure 1 shows an example of one device profile.

Hardware	
CPU	AMD Athlon
MemorySizeinMB	128
VoiceInputCapable	Yes
VoiceoutputCapable	Yes
VideoInputCapable	Yes
VideooutputCapable	Yes
Software	
VideoCodecs	MPEG-1
	MPEG-2
	H.261
	H.263
AudioCodecs	MP3
	G.711
Applications	JMF
	Vic
	Vat
	WhiteBoard

Figure 1. Device Profile

Work in the Wireless Application Protocol (WAP) Forum [9] is underway to incorporate the CC/PP emerging standard into the wireless network. Digital cellular devices are characterized by less powerful CPUs, less memory (ROM and RAM), restricted power consumption, smaller displays, different

input devices (e.g., a phone keypad, voice input, etc.); enabling the interconnection of the Web and wireless terminals requires the wireless device to expose its capabilities to the Web.

In all the previous mentioned works, the concept of user preference was absent. Most of the work concentrated on device configuration and media formats. Even though device capabilities and media formats are important, still one more centric factor is missing from the equation: the end-user.

Early work on QoS user profile can be found in [10]. A user interface is presented that allows the creation of the user profile. The user specifies the *desired* and *maximum* quality for the audio and video media (frame rate, resolution, audio quality). Three Importance values were required for each media type. These preference are stored in the user profile and used in the *Cooperative QoS Management* framework to selected media variants from the news-on-demand server. The work did not discuss how combine different preferences and there was no mention for device capabilities.

In [11], the authors presented a framework that uses the user profile data to select the best setting of QoS parameters in the space limited by the boundaries. The user of the model has to select the *minimum acceptable* and *ideal* level for each media type, together with the *sensitivity* of the user to the changes. To represent the user's perceptual quality, the paper introduced the concept of *user satisfaction* for each media type. The framework also presented a model for combining the satisfactions of different media into total satisfaction. The cost criterion was used to select between different parameters with equal satisfaction values. The authors did not consider though the device capabilities, and the selection criterion was based on one-end user only. Section 5 gives a detailed explanation of the work and talks about the suggested modifications to the model.

3. Video Telephony and Conferencing: Problem and Suggested Solution

The advances in network technology have changed the face of the world. From publishing, education, training, medicine, to entertainment, there is rarely a field in life that is not affected by these advances. Many new services, especially multimedia services are becoming indispensable parts of our daily life.

Advances in network technology did not only provide users with a multi-service multimedia platform, but it also enhanced service mobility with new technologies such as cellular telephony and mobile IP, to name a few. In addition to device mobility, personal mobility is becoming now the focus of many research projects. In the near future, users are expected to roam across different networks, using the services provided in the domain they are currently visiting. Users will also be able to use devices and services available in a visiting domain, provided that there exists an exchange policy for authentication and charging between the visiting domain and the user's home domain.

With these advances, new problems come to surface. The heterogeneity of devices, ranging from small devices to personal computers, coupled with the variety of media types, has always been an issue for multimedia communication. This diversity in communication devices has always posed limitation on compatibility. Users with non-compatible software sometimes receive media that they can not store or playback properly. Users having access to different devices should also have different configuration files for each device. This puts extra burden on the user, and encumbers personal mobility.

To benefit from all these advances and limit the drawbacks of heterogeneity, we suggest that each device has a profile that stores information about the hardware and software on that device. We also suggest that each user keeps his/her personal profile on a profile server in his home domain. A profile manager is required to provide users with the ability to create and modify their profiles. Profile managers should also provide a communication interface to profile managers in other domains to support personal mobility. The next sections discuss the content and use of these profiles.

4. User Profile and its Possible Representation

4.1. User Profile

In plain computing environment, it is only sufficient to keep an encrypted version of the user password in his/her profile to give him/her access to certain computing facilities. When a user types in his/her user id and his/her password, the system usually contacts an authentication server to determine the authenticity and authority of the user. In a multi-user Unix environment, an application may also be configured using environment parameters or using the “dot rc” file (.pinerc, .newsrc,...). Certain applications under WindowsNT such as Netscape also support multi-user configuration using the user profile. Even though the parameters in the “dot rc” or user profile are specified by the user, they were specific to the application.

In this paper, we are suggesting the use of a user-centric profile. This profile should capture the personal properties and preferences of the user. Properties include, but are not restricted to full name, employer, email account, phone number, class factor (described later) etc.. As for preferences, they can cover the parameters for all applications to which the user has access to, but we are interested here in the user's preferences concerning the quality of multimedia communication. These preferences cover the choice of receiving/sending audio and video such as the frame rate, the resolution, the audio quality and the degree of preference (weight) for every media types. Certain preferences are also related to the selection quality of individual media types for communication with particular persons. A public section for preferences may be used to specify that the user is interested in news about the stock market, and if so, the prices for the shares of certain companies. This section, we call it *public preferences section*, can be used by content providers to provide tailored advertisements and services. Figure 2 shows an example of a user profile.

Personal Identification			Callees		
Name:	Peter Alleyene		Callee	rami@wam.umd.edu	
Employer:	University of Ottawa		QoSselectionWeight	0.6	
Email	peter@site.uottawa.ca		PriceCeiling_CentsPerMinute	15	
Phone Number	613-562-5800		AudioWeightFactor	9	
ClassFactor	0.5		VideoWeightFactor	2	
Public Preferences			Callee john@nortelnetworks.com		
Music	Jazz		QoSselectionWeight	0.75	
	Blues		PriceCeiling_CentsPerMinute	30	
Sport	Soccer		AudioWeightFactor	1	
	Tennis		VideoWeightFactor	1	
			Callee www.sportsnews.com		
			QoSselectionWeight	0	
			PriceCeiling_CentsPerMinute	18	
			AudioWeightFactor	0	
			VideoWeightFactor	9	
			Callee www.newsondemand.com		
			QoSselectionWeight	0	
			PriceCeiling_CentsPerMinute	11	
			AudioWeightFactor	7	
			VideoWeightFactor	0	
VideoPreferences			AudioPreferences		
ReceiveVideo	Yes		ReceiveAudio	Yes	
SendVideo	Yes		SendAudio	Yes	
FrameRate	Min Acceptable	10	Min Acceptable	Telephone Quality	
	Ideal	30	Ideal	CD Quality	
FrameResolution	Min Acceptable	320x240			
	Ideal	800x600			
	Sensitivity Parameter	6			

Figure 2:User Profile

The profile in Figure 2 shows the profile for a user named *Peter Alleyne*. The first part of the profile represents the personal information of the user. The *Video Preferences* section describes the user's preferences to send and receive video. It also shows what is the *Minimum Acceptable* and *Ideal* values for the frame rate and resolution of the video. The *Sensitivity Parameter*, explained in Section 5, reflects the sensitivity of the user to the changes in the parameter value between the minimum and maximum rate. The same holds for the *Audio Preferences* section. In the *Callees* section, each *callee* has a unique user id (email or URL address) and a *QoSselectionWeight* parameter. This parameter will help decide how much the preferences of the callee influence the selection of the session parameters (see Section 5.2). The other two parameters, *AudioWeightFactor* and *VideoWeightFactor* reflects the preference of the user to use respectively audio and video to communicate with this callee. The *PriceCeiling_CentsPerMinute* tells the system what is the ceiling on the price if the user wants to communicate with this callee.

4.2 Representation of the User and Device Profile using the CC/PP Protocol

To represent the properties and preferences of the user in the user profile and the device profile, we consider the use of the CC/PP protocol. Using the RDF format will eliminate the interoperability problem for meta-data representation at various levels (user, hardware and software component). The W3C, IETF, and WAP Forum are working closely to avoid unnecessary divergence between the recommendations and standards. We strongly believe that using a common unified technology in the metadata representation will help resolve the interoperability problem between different levels.

Another reason for using the RDF model for representing user profiles is the automation in the selection of media types and parameters. Automating the selection procedure requires the preferences to be represented in a machine-understandable format. Figures 3 and 4 shows the previous user and device profile expressed in the CC/PP format. Details about the CC/PP are available from the W3C Forum.

```

<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:prf="http://www.site.uottawa.ca/school/research/DSRLab/elkhatib/QoS_User_Schema.0#"
<rdf:Description ID="MyProfile">
<prf:Defaults rdf:resource="http://www.site.uottawa.ca/profiles/gradProfile/">
<!overwrite the default properties .....->

<prf:Component>
<rdf:Description ID="PersonalIdentification ">
<rdf:type resource=" http://www.site.uottawa.ca/school/research/DSRLab/elkhatib/QoS_User_Schema.0/#PersonalIdentification
"/>
    <prf:Name>Peter Alleyne</prf:Name>
    <prf:employer>University of Ottawa</prf:employer>
    <prf:Email>peter@site.uottawa.ca</prf:Email>
    <prf:PhoneNumber> 613-562-5800 </prf:PhoneNumber>
</rdf:Description>
</prf:Component>

<prf:Component>
<rdf:Description ID=" VideoPreferences ">
<rdf:type resource=" http://www.site.uottawa.ca/school/research/DSRLab/elkhatib/QoS_User_Schema.0/# VideoPreferences" />
    <prf:SendVideo>Yes</prf:SendVideo >
    <prf:ReceiveVideo>Yes</prf: ReceiveVideo >

    <prf:MinAcceptableFrameRate> 10 <prf:/MinAcceptableFrameRate>
    <prf:MaxacceptableFrameRate> 30 <prf:/MaxAcceptableFrameRate>
    <prf:FrameRateSensitivityParameter> 8 <prf:/FrameRateSensitivityParameter>

    <prf:MinAcceptableFrameResolution > 320x240 <prf:/MinAcceptableFrameResolution >
    <prf:MaxacceptableFrameResolution > 800x600 <prf:/MaxAcceptableFrameResolution >
    <prf:FrameResolutionSensitivityParameter> 6 <prf:/FrameResolutionSensitivityParameter>

</rdf:Description>
</prf:Component>

<prf:Component>
<rdf:Description ID=" AudioPreferences ">
<rdf:type resource=" http://www.site.uottawa.ca/school/research/DSRLab/elkhatib/QoS_User_Schema.0/#AudioPreferences" />
    <prf:SendAudio>Yes</prf:SendAudio >
    <prf:ReceiveAudio>Yes</prf: ReceiveAudio >
    <prf:MinAcceptableAudioQuality> Telephone <prf:/ MinAcceptableAudioQuality >
    <prf:MaxacceptableAudioQuality> CD <prf:/MaxAcceptableAudioQuality>

```

```

    <prf:AudioQualitySensitivityParameter> 5 </prf:AudioQualitySensitivityParameter>
  </rdf:Description>
</prf:Component>

<prf:Component>
  <rdf:Description ID="Public_Preferences">
  <rdf:type
  resource="http://www.site.uottawa.ca/school/research/DSRLab/elkhatib/QoS_User_Schema.0/#Public_Preferences" />
    <prf:Music>
      <rdf:bag>
        <rdf:I> Jazz</rdf:I>
        <rdf:I> Blues </rdf:I>
      </rdf:bag>
    </prf:Music>

    <prf:Sport>
      <rdf:bag>
        <rdf:I> Soccer </rdf:I>
        <rdf:I> Tennis </rdf:I>
      </rdf:bag>
    </prf:Public_Preferences>
  </rdf:Description>
</prf:Component>

</rdf:Description>
</rdf:RDF>

<prf:Component>
  <rdf:Description ID="CalleeList">
  <rdf:type resource="http://www.site.uottawa.ca/school/research/DSRLab/elkhatib/QoS_User_Schema.0/#CalleeList" />

    <prf:Component>
      <rdf:Description ID="Callee">
      <rdf:type resource="http://www.site.uottawa.ca/school/research/DSRLab/elkhatib/QoS_User_Schema.0/#Callee"
  />

        <prf:CalleeId>rami@wam.umd.edu </prf:CalleeId>
        <prf:ClassFactor> 0 </prf:ClassFactor>
        <prf:AudioWeightFactor> 9 </prf:AudioWeightFactor>
        <prf:VideoWeightFactor> 2 </prf:VideoWeightFactor>
      </rdf:Description>
    </prf:Component>

    :
    :

  </rdf:Description>
</prf:Component>

```

Figure 3. User Profile of Figure 2 Expressed in RDF

```

<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:prf="http://www.site.uottawa.ca/school/research/DSRLab/elkhatib/deviceschema1.0#">
  <rdf:Description ID="MyDevice">

    <prf:Component>
      <rdf:Description ID="TerminalHardware">
      <rdf:type resource="http://www.wapforum.org/UAPROF/ccppschemal.0/#HardwarePlatform" />
        <prf:Defaults rdf:resource="http://www.DeltaComputers.com/profiles/PC2160" />
        <!-- override the ImageCapable property and add VoiceInputCapable and Keyboard properties -
  ->

        <prf:CPU>AMD Athlon </prf:CPU>
        <prf:MemorySize> 128 </prf:MemorySize>
        <prf:VoiceInputCapable>Yes</prf:VoiceInputCapable>
        <prf:VoiceoutputCapable>Yes</prf:VoiceoutputCapable>
        <prf:VideoInputCapable>Yes</prf:VideoInputCapable>
        <prf:VideooutputCapable>Yes</prf:VideooutputCapable>

      </rdf:Description>
    </prf:Component>

    <prf:Component>
      <rdf:Description ID="TerminalSoftware">
      <rdf:type resource="http://www.wapforum.org/UAPROF/ccppschemal.0/#SoftwarePlatform" />

```

```

<prf:Defaults rdf:resource="http://www.symbian.com/profiles/pda/epoc" />
  <!--Specify VideoInputEncoder and AudioInputEncoder properties -->
  <prf:VideoCodecs>
    <rdf:Bag>
      <rdf:l>MPEG-1</rdf:l>
      <rdf:l>MPEG-2</rdf:l>
      <rdf:l>H.261</rdf:l>
      <rdf:l>H.263</rdf:l>
    </rdf:Bag>
  </prf:VideoCodecs>

  <prf:AudioCodecs>
    <rdf:Bag>
      <rdf:li>MP3 </rdf:li>
      <rdf:li> G.711</rdf:li>
    </rdf:Bag>
  </prf:AudioCodecs>

</rdf:Description>
</prf:Component>

</rdf:Description>
</rdf:RDF>

```

Figure 4. Device Profile of Figure 1 Expressed in RDF

5. Automatic QoS Parameter Selection

Before engaging in a telecommunication session, a decision has to be made as to what hardware components to use (camera, speakers, microphone,..), which software to start (Vic, Vat, whiteboard), what type of media to use (MPEG1, H.261), and the quality of the presentation of the media (frame rate, frame resolution, audio quality,...). This decision is affected by many factors including the hardware and software profile of the devices to be used, referred to as limitations, and the properties, preferences, and privileges of end users. This suggests that the device and user profiles of all end-users should be merged to come up with a profile for the communication session. We consider in the following a communication session between two users.

The first step in the selection procedure consists of selecting the possible interoperable hardware and software components in the devices of the two users. A device that does not have an MPEG-1 codec renders the communication with other devices sending MPEG-1 media type impossible. Also a device which does not have a speaker can not support a telephony session. To construct the list of compatible components, the profile of all devices should be merged together. Information about compatibility could be stored in a central database, and fed into the selection process.

As an example, let us assume that one of the devices is described by the profile of Figure 1, and that this second device has the following components: camera, speaker, MPEG-1 codec, G.711, MP3 codec. Merging the two profiles of the devices should reveal that MPEG-1 and G.711 codecs could be used. While the two devices can send and receive video media, one of the devices can only receive audio media since it does not have a microphone.

The second step in the selection procedure consists of selecting specific parameter values for certain QoS parameters, such as video frame rate and resolution, within the bounds imposed by the limitations of the device hardware and available network service. For instance, the network access line of one of the devices may limit the maximum throughput (e.g. modem or wireless connection). Another device may have a small display area which limits the resolution of the video. Another limitation may be imposed by the user by establishing a maximum cost per minute (which may depend on the effective

network throughput used). Within these limits, the most appropriate QoS parameter values should be selected during this second step. In order to optimize this selection process, it is important to consider the user's preferences, as indicated in his user profile.

5.1. Quantifying the user preferences

In order to take the user preferences into account during this second step of QoS parameter selection, we have to quantify the preferences of the user. An interesting approach has been described in [11]. The paper considers several QoS parameters x_i representing different aspects of the quality of various multimedia components and considers the user's appreciation of these parameters. The appreciation of a user is expressed by a "satisfaction function" g_i which determines the "satisfaction" s_i of the as a function of the value x_i of the corresponding parameter, that is, $s_i = g_i(x_i)$. The values of the satisfaction lie between the values zero and one (as indicated in Figure 5), which corresponds to the minimum acceptable value (M) and an ideal value (I).

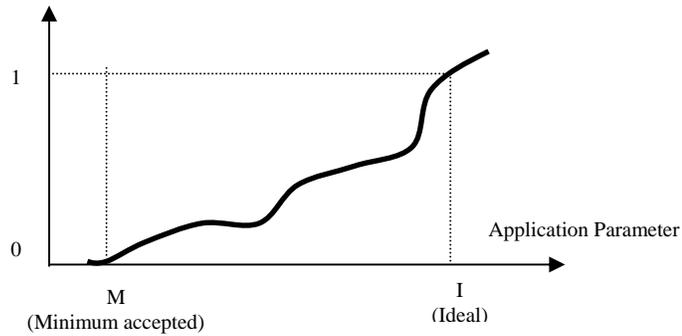


Figure 5. Example of the mapping function determining the user satisfaction depending on the value of a QoS

It is noted the satisfaction function $s(x)$ should increase monotonically. Since the exact form of the user satisfaction function is difficult to determine, various forms of monotonically increasing functions are proposed in [11]. In this paper we assume the simplest case where the satisfaction function is linear between the two points of minimum acceptable and ideal values, and constant outside that interval. This means that $s(x)$ is zero for values of x smaller than M , equal to one for value of x larger than I , and for values in between M and I the satisfaction is given by the formula

$$s(x) = \frac{1}{I - M}(x - M)$$

In the case when there are more than one application parameter their respective satisfaction functions, a combined satisfaction S_{tot} should be computed. The authors of [11] propose combination function f_{comb} which determines the total satisfaction S_{tot} from the satisfactions s_i for the individual parameters as follows:

$$S_{tot} = f(s_1, s_2, s_3, \dots, s_n) = \frac{n}{\sum_{i=1}^n \frac{1}{s_i}} \quad (\text{Equa. 1})$$

f_{comb} has the following properties:

- 1- One individual low satisfaction is enough to bring the total satisfaction to a low value. This property of the function is essentially saying that if the user is not satisfied with one of the parameters, then he is not satisfied in total.
- 2- The total satisfaction of equal individual satisfactions s_i is equal to the satisfactions s_i .

We note that f_{comb} is a many to one mapping function, and hence different combinations of individual satisfaction values are possible for one value of S_{tot} . To find out what the best possible combination of individual satisfaction functions is, another selection criterion is needed. The most reasonable selection criterion is the cost. Providing a tariff structure which determines the cost for the different values x_i of the individual application parameters, one can devise an optimization strategy for finding application parameter values that minimize the cost for a given global S_{tot} [11].

5.2 Weighted Combination of User's Preferences

We think that the approach described above is a major step towards a simple user-friendly interface for user level QoS specification, however, further considerations could be taken into account as described below. A first improvement results from the observation that users in telecommunication session might find some media types more important than others. For instance, a user of a news-on-demand service might prefer to receive high quality audio with low quality video as compared to average quality audio and average quality video. In the case of a user watching a sport event the situation may be the opposite (if the user does not care about the audio of the commenter).

This preference to individual media can play a factor when it comes to the calculation of the total satisfaction S_{tot} . By assigning different weights w_i to the different parameters x_i , S_{tot} will reflect the user preference for different media types. The combination function for the total user satisfaction can be redefined as follows:

$$S_{tot}^{user} = f_{comb}(s_1, s_2, s_3, \dots, s_n, w_1, w_2, w_3, \dots, w_n) = \frac{n\bar{w}}{\sum_{i=1}^n \frac{w_i}{s_i}} \quad (\text{Equa. 2})$$

where w_i is the weight for the individual satisfunction s_i and $\bar{w} = \frac{\sum_{i=1}^n w_i}{n}$.

These constants weights factors are selected by the user, and they are stored in the user profile (AudioWeightFactor, VideoWeightFactor,..). The selection of these weights depends on the type of service the user is willing to receive when using a specific service or communicating with a given callee.

5.3. Combining Preferences of Several Users

So far we have only considered the QoS preferences of a single user. But all conversational multimedia applications involve several users. It is therefore important to determine how the possibly conflicting preferences of the different users are reconciled in order to come up with QoS parameters which are suitable for all participating users.

In certain circumstances, some given parameters may be determined simply based on the preferences of a single user. This may be the case in a two-way teleconference between two users A and B, where the parameters of the video visible by User A would be determined based on the preferences of User A alone, and the video in the opposite direction based on the preferences of User B. However, the situation may be more complex if the cost of the communication is paid by User A and the selection of the video received by User B has an impact on the communication cost.

In other circumstances, as for instance in the case of the joint viewing of a video clip by several participants in a teleconference, the selected quality parameters should be determined based on the

preferences of all participating users. In such circumstances, we propose to use the same combination function for user satisfaction considered above and (optionally) introduce a weight for each of the participating users, called the *QoS selection weight*, which determines how much the preferences of the user influence to overall QoS parameter selection. The total satisfaction (computed for all users) is then given by

$$S_{tot} = f_{comb}(s_{tot}^{usr_1}, s_{tot}^{usr_2}, \dots, s_{tot}^{usr_n}, a_1, a_2, \dots, a_n) \quad (\text{Equa. 3})$$

where $s_{tot}^{usr_i}$ is the total satisfaction for user i , and a_i is the *QoS selection weight* for user i . In the case that the weight of a given user is zero, the preferences of this user are not taken into account for the selection of the QoS parameters.

6. An Example Scenario

Let us consider the example where two users, A and B, want to view a video clip during a teleconference. We assume that the hardware and software constraints on the communication devices used by the two users allow for the following values of QoS parameters: (a) video frame: 10, 12, 14, ...30 frames per second, and (b) resolution: 180x240, 240x320, 300x400, 360x480, 420x560, or 480x640. For each of the possible combination of frame rate and resolution values, we may determine (using Equation 2) the satisfaction of each of the two users based on their respective QoS preferences stored in their user profile. Some of these combination may not be feasible because the corresponding throughput can not be supported by the network access interface of one of the users.

We may now use Equation 3 to determine the overall user satisfaction, taking into account the QoS selection weights of the two users. These weights may be determined by the user that initiated the teleconference and pays for its cost. Examples of such weights are indicated in the user profile of Figure 2. If the communication cost is no issue, the selection of the QoS parameters would be based on the optimization of the overall user satisfaction, that is, the combination of frame rate and resolution that optimizes the overall user satisfaction will be adopted.

This means that if the weight of User B is zero, only the preferences of User A will be used for the selection of the video QoS parameters. If that user has specified in his user profile a high weight for frame rate and a low weight for resolution, the selected video quality will trade-off high frame rate against low resolution when the available network throughput limits be available possibilities. On the other hand, if the QoS selection weights of User B is larger than for User A and the user profile of User B specifies low weight for frame rate and high weight for resolution, then the optimization will follow more the preferences of User B, that is, a video quality with higher resolution will be selected.

7. Conclusion

To control and select the QoS parameters for a communication session, a user profile that keeps the user's preferences for each media type is suggested. The combination of the user preferences and the limitation of the used device is outlined. We also presented an extension to the framework presented in [11] to enable weight assignment to different preferences. The extended framework will also considers the preferences of the different participants in a session.

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