

A Study on a QoS/QoE Correlation Model for QoE Evaluation on IPTV Service

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Abstract— We develop a QoS/QoE correlation model for IPTV QoE evaluation. With the growth of QoE interest, IPTV providers need a method to control QoE when QoE is not satisfied by subscribers. Network providers can evaluate subscriber's QoE using QoS parameters weight and some analyzed values which is from the proposed model, and control QoE as deduce QoS parameters(delay, loss, jitter etc) associated with QoE. Through our proposed QoS/QoE correlation model, network providers can predict subscribers' QoE value in offered network environment and, on the contrary, constitute network environment which can meet an optimum QoE.

Keywords— IPTV, QoS, QoE, NGN, QoS/QoE correlation model

I. INTRODUCTION

The various access network technologies are integrated through NGN(Next Generation Network). Also various multimedia services(e.g. IPTV, VoD(Video on Demand), VoIP(Voice over IP), Image Conference, and etc) are provided by a network and service providers in the NGN environment. Particularly, the IPTV service replaces the preexistence analogue television, with the various services(Live TV, VoD, T-Commerce, Walled Garden service, and etc) through the Internet.

IPTV service environment has been under a dramatic change along with the IPTV market growth and subscribers' demanding requirements. In this situation, it is necessary to improve IPTV service in the viewpoint of the quality that maximizes a subscriber's experience. As various multi-media services are provided in the integrated network environment(NGN), QoS(Quality of Service) and QoE(Quality of Experience) concept is introduced in the IP network to describe satisfactions about subscriber's quality requirements.

QoE is the term which is used to describe how it is satisfied by subscribers to the provided service quality. The poor QoE will cause dissatisfied subscribers and fall behind in contestants due to the ultimately bad market competitive power to contestants. QoE is composed of not only the network performance parameter but also the service quality parameter such as cost, reliability, availability, usability, and

fidelity. Although QoE is very subjective in nature, it is very important that a strategy is devised to measure it as realistically as possible. The ability to evaluate QoE will give the provider some sense of the contribution of the network's performance to the overall level of subscriber satisfaction.

There are numerous network-related features affecting IPTV service quality. To manage the service quality effectively, the IPTV QoE should be monitored and kept in good condition by service providers. However, QoE-related QoS parameters have the different influence and they cannot be treated in a same weight. So, An IPTV QoS/QoE correlation model needs to assign QoS parameter weights and to analyze hierarchical relationships of QoS parameter and QoE items.

The investigation of a correlation between QoS and QoE has been being progressed in order to solve the limit of the satisfaction evaluation. According to NP(Network Performance), QoS and QoE items, the existing researches[1][2] deduced the major quality elements of the IPTV service. They used the QDF(Quality Deployment Function) methodology for analysis of relationship between the drawn QoE items and the QoS parameters.

However, it was not actually studied about the method for evaluating the IPTV QoE. They just analyzed a relationship of QoS parameters and QoE items and don't present a method for QoE evaluation.

In the IP-based network environment, the existing research [3] for the image multimedia service QoE measurement has considered only the IP Packet Loss and Bandwidth among the QoS quality parameters. However, the various QoS parameters causing an effect in the QoE of the IPTV service aren't reflected in [3]. For this reason, it is not adequate to evaluate the subscriber satisfaction of the IPTV service in future.

In order to solve the problem of the existing researches, we develops the QoS/QoE correlation model to numerically evaluate the IPTV QoE by using preexisting researches' results[1][2]. Through our proposed model, service provider can predict subscriber's QoE in provided network environment and analogize service environment which meet the optimum QoE, conversely.

The rest of the literature is organized as follows. In section 2, we explain a development procedure of QoS/QoE correlation model for IPTV QoE evaluation using preexisting results[1][2].

In section 3, we show the example of IPTV Video QoE evaluation using the proposed model, and present a conclusion in section 4.

II. RELATED WORKS

A. The voice and video service quality measurement method

Existing quality assessment technologies can be classified into two categories: subjective quality assessment schemes and objective ones. Current research status of these two kinds of evaluation methods are illustrated as followed paragraphs:

Currently, the evaluation methods for the speech service are mature. For subjective evaluation methods, opinion rating (MOS) based on customer's satisfaction has been studied to assess the perceptual QoS. It is specified in ITU-T recommendations E.800 initially [9]. On another hand, several objective quality assessed methods has been proposed in ITU-T, such as P.861[10] PSQM (Perceptual Speech Quality Measure), P.862[11] PESQ (Perceptual Evaluation of Speech Quality) and G.107 E-Model[12].

For the video service evaluation, subjective video quality evaluation method is the most reliable video quality measurement method. A group of viewers is selected and gathered in a room, the measurement environment is specified in the ITU-T Recommendation P.910[13]. For the research of objective video quality method, some estimation software has been developed which can analyze the video signals and produce the quality evaluation results. One traditional objective video quality measurement, Peak Signal to Noise Ratio (PSNR), has been widely used in many applications to assess video quality.

PSNR does not take the visual masking phenomenon into consideration. In other words, every single pixel error contributes to the decrease of the PSNR, even if this error is not perceived. So, MPQM (Moving Pictures Quality Metric) was proposed for the objective the video quality measurement[14][15]. MPQM is an objective quality metric for moving picture which incorporates human vision characteristics. MPQM represents the typical image quality assessment models based on the error sensitivity. The widely adopted assumption of these models is that the loss of perceptual quality is directly related to the visibility of the error signal.

From current research status of evaluation method, we can see that the subjective method based on user survey can reflect the experience of user more directly and match well to the feeling of user. However, this kind of method has several problems, such as, it required special environment and equipments, needs a mass of people to participate the test. In conclusion, subjective video quality measurement cannot provide real-time and in-service quality monitoring for real-time video applications. So the application of the method is limited.

B. The study of relationship between QoS and QoE

Currently, the investigation of QoS and QoE correlation is continued. Khirman and Henriksen were trying to relate the objective network service conditions with the human perception of the quality of the service. Their subject has been widely investigated for voice delivery and it is widely acknowledged that the relationship between voice transmission conditions and the human perception of quality is far from linear[16]. They discuss in detail how the human satisfaction of HTTP service is affected by the two main network QoS parameters, namely network delivery speed and latency. However, it is difficult to represent the feature of the provided and various services from only the bandwidth and latency time in the integrated network environment.

In [17] the authors thought that pervasive computing environment brings the method of evidence context related to QoE. They studied the QoE evaluation method in pervasive computing environment, and proposed the enhanced QoE evaluation parameter model. In [17] rough-set based algorithm is proposed to reduce context attributes and determine the weight of each attribute, the algorithm has been validated on video streaming service, and the architecture of QoE evaluation system is described. As a mass of evidence information related to the experience of users can be gathered through the context-awareness computing, the calculation results of QoE evaluation method can highly match the real feeling of users. However, the method needs to be enhanced along with the development of pervasive computing.

III. THE QOS PARAMETERS ANALYSIS RELATED TO END-USER EXPERIENCE

This clause addresses the QoS quality parameters which can be considered for the QoE evaluation. Transfer Capacity is a fundamental QoS parameter having primary influence on the performance perceived by end-users. Many user applications have minimum capacity requirements; these requirements should be considered when entering into service agreements. And lost bits or octets can be subtracted from the total sent in order to provisionally determine network capacity. An independent definition of capacity is for further study.

It is assumed that the user and network provider have agreed on the maximum access capacity that will be available to one or more packet flows in a specific QoS class (except the Unspecified class in Table 1). A packet flow is the traffic associated with a given connection or connectionless stream having the same source host (SRC), destination host (DST), class of service, and session identification. Other documents may use the terms microflow or subflow when referring to traffic streams with this degree of classification. Initially, the agreeing parties may use whatever capacity specifications they consider appropriate, so long as they allow both network provider enforcement and user verification. For example, specifying the peak bit rate on an access link (including lower layer overhead) may be sufficient. The network provider agrees

to transfer packets at the specified capacity in accordance with the agreed QoS class.

The network performance objectives may no longer be applicable when there is packets submitted in excess of the capacity agreement or the negotiated traffic contract. If excess packets are observed, the network is allowed to discard a number of packets equal to the number of excess packets. Such discarded packets must not be included in the population of interest, which is the set of packets evaluated using the network performance parameters. In particular, discarded packets must not be counted as lost packets in assessing the network's IPLR performance. A discarded packet might be retransmitted, but then it must be considered as a new packet in assessing network performance.

Each network QoS class creates a specific combination of bounds on the performance values. This clause includes guidance as to when each network QoS class might be used, but it does not mandate the use of any particular network QoS class in any particular context.

Table 1. IP NETWORK QoS CLASS DEFINITIONS AND NETWORK PERFORMANCE OBJECTIVES [18]

Network performance Parameter	QoS Classes					
	Class 0	Class 1	Class 2	Class 3	Class 4	Class 5
IPTD	100 ms	400 ms	100 ms	400 ms	1s	U
IPDV	50ms	50ms	U	U	U	U
IPLR	1×10^{-3}	1×10^{-3}	1×10^{-3}	1×10^{-3}	1×10^{-3}	U
IPER	1×10^{-4}					U

A. Network delay

Delay manifests itself in a number of ways, including the time taken to establish a particular service from the initial user request and the time to receive specific information once the service is established. Delay has a very direct impact on user satisfaction depending on the application, and includes delays in the terminal, network, and any servers. Note that from a user point of view, delay also takes into account the effect of other network parameters such as throughput.

B. Network delay variation (Jitter)

Delay variation is generally included as a performance parameter since it is very important at the transport layer in packetized data systems due to the inherent variability in arrival times of individual packets. However, services that are highly intolerant of delay variation will usually take steps to remove (or at least significantly reduce) the delay variation by means of buffering, effectively eliminating delay variation as perceived at the user level (although at the expense of adding additional fixed delay).

C. Packet Loss

Packet loss has a very direct effect on the quality of service finally presented to the user, whether it be voice, image, video or data. In this context, information loss is not

limited to the effects of bit errors or packet loss during transmission, but also includes the effects of any degradation introduced by media coding for more efficient transmission (e.g. the use of low bit-rate speech codecs for voice).

Table 2. GUIDANCE FOR IP QoS CLASSES [18]

QoS class	Applications (ex)	Network techniques
0	Real-time, jitter sensitive, high interaction (VoIP, VTC)	Constrained routing and distance
1	Real-time, jitter sensitive, interactive (VoIP, VTC)	Less constrained routing and distances
2	Transaction data, Highly interactive (Signaling)	Constrained routing and distance
3	Transaction data, interactive	Less constrained routing and distances
4	Low loss only (short transactions, bulk data, video streaming)	Any route/path
5	Traditional applications of default IP networks	Any route/path

IV. QoS/QoE CORRELATION MODEL FOR IPTV QoE EVALUATION

A. The Normalized QoS Value

As mentioned in the above, the user satisfaction about IPTV is under the influence of various QoS parameters. So, we limit a scope of QoE in this paper to the satisfaction about the video QoE of the IPTV service because overall QoE of the IPTV complexly consists of the variant QoE items.

It is known from the QoS/QoE relationship analysis that the most of QoE items are related with the QoS parameters. Moreover, according to the analysis results of QoS correlation, many QoS items show the positive correlation with QoE items. In order to reflect variance QoS quality parameters in QoE evaluation, the normalized QoS value calculation procedure needs.

It can classify into the IPTV Video QoE items such as a resolution, color error, block distortion, jerkiness and etc. The QoS parameters having an effect on these QoE items are IP Packet Loss, IP Packet Delay, IP Packet Jitter, Bandwidth, and etc. These QoS parameters are network-related quality elements which the standardization organizations like ITU-T and IETF recommend.

Firstly, service providers carry out the measurement of the QoS parameters which are considered at the network layer. Through the quality control protocol like RTCP(Real-time Transfer Control Protocol), the quality management system for the IPTV service can measure and collect the QoS parameters. The next step, they should normalize the QoS guaranteed level by using the measured parameters. Here, the weighted value of the QoS parameters can be assigned through the relative importance degree of the QoS parameter about the IPTV Video QoE and QoS/QoE correlation analysis results. Table 3 shows the network-related QoS parameters and its relative importance degree of IPTV service.

Table 3. The example of Network-related QoS parameters and its Relative Importance Degree of IPTV service

QoS parameters	Relative Importance Degree
Packet Loss (L)	41.7 %
Burst Level (U)	29.2 %
Packet Jitter (J)	10.7 %
Packet Delay (D)	10.6 %
Bandwidth (B)	7.8 %

We can assign the weighted value of QoS parameters according to the quality standard bounds recommended in the standardization organizations(e.g. ITU-T, IETF etc) and its relative importance degree represented in the Table 3. Also, the weighted value of each parameter is differentially given according to the scope of the measured QoS quality parameters.

The normalized QoS value which reflects the network condition can be calculated through the formula (1). In the formula (1), the constant K means the whole QoS quality determinant which is selected according to the type of the access network for the IPTV service. According to the type of access network type(wired and wireless), this value is differently given.

$$QoS(X) = K\{L \times Wl + U \times Wu + J \times Wj + D \times Wd + B \times Wb...\} \quad (1)$$

The normalized QoS value can be simply calculated with the total sum of the values multiplying the measured QoS parameter in network layer with the allocated weight like the formula (1). In the formula (1), it is just referred to the major QoS parameters influencing on the IPTV Video QoE. The QoS parameter items used in this formula may be expanded and applied according to the characteristic of a service in case of considering the other multimedia services.

B. The QoS/QoE Correlation Model for IPTV Video QoE Evaluation

The numerical formula model to evaluate the subscriber's IPTV Video QoE($QoEv$) by using the normalized QoS value is as follows:

$$QoEv = Qr \times (1 - QoS(X))^{\frac{QoS(X) \times A}{R}} \quad (2)$$

In the formula (2), Qr is a coefficient limiting the range of the IPTV image QoE according to the display size and/or resolution of the terminal. For example, as the display size of the terminal is large, the user's quality satisfaction may be higher measured about the same resolution. So we use this constant in order to reflect these features. Next, the $QoS(X)$ is the normalized value of quality level which is calculated by

the formula (1), and is determined by quality parameters of the network layer.

Next, the constant A expresses the subscribed service class. If the subscribed service class is high, the constant A is assigned in the higher value. It means that QoE level which the premium service subscriber's requests is high than the general service subscriber's in the network condition of the same QoS quality.

Finally, R is determined as the constant reflecting the structure of the video frames according to the GoP(Group of Picture) length. Because an encoding is not progressed in case of losing an I-Frame until the next I-Frame is received, the loss of an I-Frame more induces the poor quality(frame skipping, frame freezing etc) than the other frames(P/B-Frame). So, we can use the variable R as the factor for the image QoE measurement.

A variable and the constant used in this model are determined by elements causing an effect in the image QoE. These elements include a service environment where the terminal is positioned, a service kind, a used codec, and etc. The axis of abscissas shows the normalized QoS value in which of the network environment is reflected, and the service satisfaction of subscribers(QoE) corresponds to the longitudinal axis accordingly. The user satisfaction is mapped in 5 classes of the preexistence MOS (Mean Opinion Score) score.

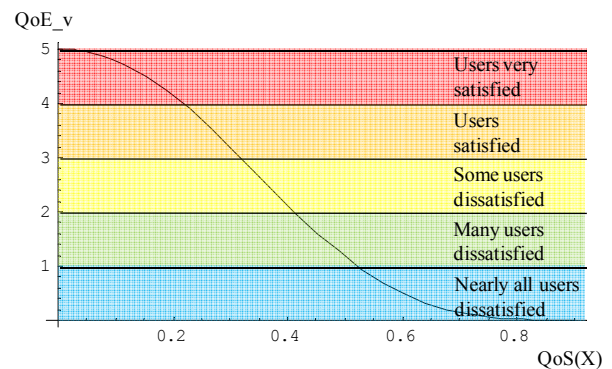


Figure 1. QoS/QoE Correlation Model for IPTV

V. AN EXAMPLE OF THE IPTV VIDEO QoE EVALUATION USING THE QoS/QoE CORRELATION MODEL

Table 4 shows the example of QoS parameters and its weighted value according to the relative importance degree for IPTV service(Table 3). Here, the used QoS parameters consider only the key parameters influencing on the IPTV Video QoE, and the weighted value of each parameter is allocated according to the scope of the recommendation standards in the ITU-T Y.1541[4] and DSL Forum[5].

In the same network environment as in the below, the subscriber's satisfaction of the IPTV service can be expressed like figure 2. The reason showing the mutually different QoE is due to the difference of the quality level required according to the subscribed service class.

- Case_1: MPEG-4 HDTV service
- Packet Loss = 2.78E-06 ($Wl=8E+04$)
 - Burst Level = 1.67ms ($Wu=10$)
 - Packet Jitter = 37ms ($Wj=0$)
 - Packet Delay = 105ms ($Wd=0.5$)
 - Bandwidth = 8Mbps ($Wb=2.0E-10$)
 - GoP Length = 12, $Qr = 5$
- ✱ $QoS(X) = 0.27817 \rightarrow QoEv = 2.94617$

- Case_2: MPEG-4 SDTV service
- Packet Loss = 2.78E-06 ($Wl=1.5E+04$)
 - Burst Level = 1.67ms ($Wu=20$)
 - Packet Jitter = 37ms ($Wj=0$)
 - Packet Delay = 105ms ($Wd=0.5$)
 - Bandwidth = 8Mbps ($Wb=0$)
 - GoP Length = 12, $Qr = 4.5$
- ✱ $QoS(X) = 0.09754 \rightarrow QoEv = 4.24475$

Table 4. The Example of QoS Parameters and its Weighted Value according to the Relative Importance Degree for IPTV Service

Service	Parameter	Scope	Weight
MPEG-4 AVC/VC-1 SDTV	Packet Loss (41.7%)	7.31E-06	$Wl=1.5E+04$
		5.85E-06	$Wl=1.5E+04$
		4.35E-06	$Wl=1.5E+04$
	Burst Level (29.2%)	3.75ms	$Wu=20$
		Less than 3ms	$Wu=20$
	Packet Jitter (10.7%)	Less than 50ms	$Wj=0$
		Over 50ms	$Wj=1$
	Packet Delay (10.6%)	Less than 100ms	$Wd=0$
		Over 100ms	$Wd=0.5$
	Bandwidth (7.8%)	2.0Mbps	$Wb=7E-09$
		2.5Mbps	$Wb=6E-09$
		Over 3.0Mbps	$Wb=0$

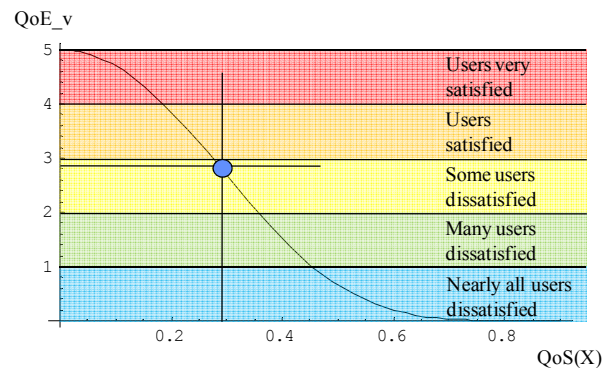
(a) QoS Parameter Weights of IPTV Service in SDTV Class

Service	Parameter	Scope	Weight
MPEG-4 AVC/VC-1 HDTV	Packet Loss (41.7%)	1.28E-06	$Wl=8E+04$
		1.24E-06	$Wl=8E+04$
		1.22E-06	$Wl=8E+04$
	Burst Level (29.2%)	0.65ms	$Wu=10$
		0.64ms	$Wu=10$
		Less than 0.63ms	$Wu=10$
	Packet Jitter (10.7%)	Less than 50ms	$Wj=0$
		Over 50ms	$Wj=1$
	Packet Delay (10.6%)	Less than 100ms	$Wd=0$
		Over 100ms	$Wd=0.5$
	Bandwidth (7.8%)	8Mbps	$Wb=2.0E-10$
		10Mbps	$Wb=1.8E-10$
		Over 12Mbps	$Wb=0$

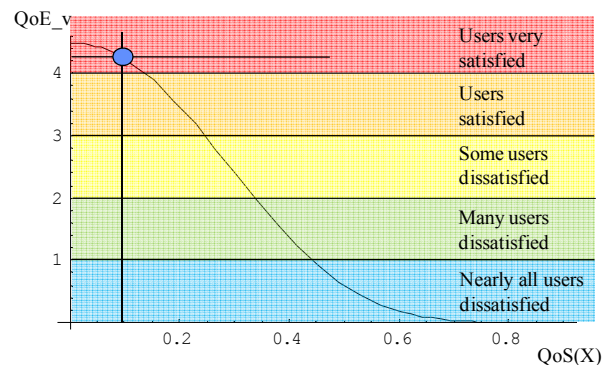
(b) QoS Parameter Weights of IPTV Service in HDTV Class

Like this, the IPTV Video QoE of subscribers can be differently expressed according to the characteristic of the subscribed service. Therefore, by using the QoS/QoE correlation model, network and/or service providers can expect the QoE of the afforded service.

The network quality parameter, weight value and the standards used for the QoE evaluation may be not perfect. In order to complement this defect, the weighted value analysis if the QoS parameters about the various services and the investigation of the service satisfaction against subscribers should be carried out.



(a) Case_1: HDTV Class



(b) Case_2: SDTV Class

Figure 2. The Image QoE Measurement Example of the IPTV Service

VI. CONCLUSIONS AND FURTHER STUDY

We propose the method to numerically measure the image QoE of IPTV by using the QoS parameters measured in the network layer and the QoS/QoE correlation analysis results. Through our proposed model, network providers can predict subscriber's QoE in provided network environment and analogize service environment which meet the optimum QoE on the contrary.

On a real time basis, it is more rapidly able to correspond to the poor quality by monitoring the QoE of the IPTV service. The service provider can provide the multimedia service of the improved QoE through the proposed QoE control processes. And moreover, the network operator can prevent the unnecessary investment for the enlargement, maintenance and repair of the network. The wide question survey should be performed against service subscribers in the future in order to reduce a gap of the user's satisfaction with the measured QoE class actually.

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