

A Study on QoS/QoE Correlation Model in Wireless-network

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Abstract—With the rapid development of wireless network technologies and multimedia communications, video services play an increasingly important role in network communications. Most traditional quality assessment methods of video services are designed based on QoS (Quality of Service, QoS) evaluation parameters. Subject test represents the most reliable quality evaluation method and QoE (Quality of Experience) is usually to be used to represent the subjective evaluation for network communications. Compared with QoE from the subjective test, QoS parameters are much easier to be obtained. In this paper, we use a QoS/QoE mapping assessment model for the relationship between QoS and QoE and test it by the experiments in NS2 network simulation environment. Experimental results demonstrate that the QoE can be obtained by QoS parameters in network communications.

I. INTRODUCTION

With the rapid development of wireless network technologies, various wireless Internet based on multimedia services has emerged. The development of network will promote rapid updates of mobile data services. Wireless network services brought huge benefits to operators, at the same time; it also makes the competition more intense between operators. So in order to get existing users and attract more new users, operators should provide a good service experience, thereby increasing end-user satisfaction. End-user quality of experience (QoE) is a decisive factor whether network services can achieve success and rapid growth. Due to users' dissatisfaction with the product or service, they will not use the service continuously. More importantly, it will cause a chain reaction, because a customer who does not satisfy a service will bring the dissatisfaction to other 13 people [1]. Thus to avoid this situation is to keep enhancing the end-user QoE and QoS.

QoE and QoS are two mutually dependent term. QoE is the user's perception of quality for online video. By experiences and perceptions about services of online video from the users' point of view, such as feeling good, feeling ordinary, feeling bad and so on, and using quantified parameters it will be obtained, we regard QoS as a technical concept, which mainly refers to the level of service guaranteed by the network parameters adjustment. From the perspective of the network, considering service of the point to point, we perform network services management and give the differences of services. So the better the end to end QoS, the better QoE we get.

In related work, factors affecting QoE can be divided into two categories: the first category is the psychological and social factors, such as cultural experiences, emotional and cognition [2]. The second category is multimedia transmission-related parameters and encoding. During transmission, the packet loss and bit error can affect the quality of video [3]. Other parameters can also affect users' satisfaction, such as users' interest, the attributes and types of the display screen, the viewing conditions (lighting, distance, etc.), and audio and video synchronization were mentioned in [4]. Many researchers also proposed the perceived quality of the video and image. Literature integrated the merits of the existing quality assessment metrics with the guide of the recently revealed internal generative mechanism (IGM). Ref. [5] only considered coding distortion. Ref. [6] considered the video content features; Ref. [7] combined video content and coding distortion to propose a new evaluation model and [8] proposed a packet-layer model of content adaptation, considering the distortion of the video in terms of time and space complexity. Ref. [9] introduced the access network, indicating that there are factors that affect the quality of the video. These factors are encoding distortion, the video content and the access network parameters. We can obtain QoE from experiment results of these documents. Our task is to obtain similar results by only analyzing the QoS parameters.

The remainder of this paper is organized as follows: Section II discusses related work about the experiment and makes some preparations. The experimental environment is described in detail in Section III and simulation results performance analyses are discussed in Section IV. In Section V, a general conclusion is presented.

II. RELATED WORK

The main factors in the transmission network that influence the QoE of video services, as shown in Table I, include the available bandwidth, packet loss, jitter, delay and other QoS metrics. According to the existing references [8-10], the network parameters and their corresponding video quality are in Table II. We associate QoE of the video services and networked QoS indicators, so that we can predict QoE of video services by QoS parameters, which has a very important significance in identifying network problems, optimizing

network performance and further improving the user experience.

A. The Normalized QoS Parameters

As noted above, QoS parameters affect the user's satisfaction. These network-related standards of QoS parameters are set by the standardization organizations, ITU-T, IETF and so on. As the overall QoE contains many elements, including users' integrated subjective feelings for equipments, networks, systems, video services and so on. But this paper is limited to the user satisfaction of video QoE. According to correlation analysis, QoS and QoE show a positive correlation. In order to reflect the variance of QoS quality parameters in QoE evaluation, we need to normalize the value of the QoS.

First, we measured QoS parameters of the network layer by network simulation. Next, QoS parameters were normalized. The relative importance degree of QoS parameters were obtained by correlation analysis of QoS and QoE of the video, and then arranged the weighting values of QoS parameters. Table III shows the relative importance degree of the QoS parameters which associate with the network and its video services.

TABLE I
NETWORK-RELATED QoS PARAMETERS AND ITS INFLUENCE ON VIDEO QUALITY

QoS parameters	Influence on video quality
Packet Loss (L)	The loss of packet especially the loss of the key frame is main reason that causes the deterioration of video image quality.
Packet Jitter (J)	Clients can only play stable video streams generally. When the jitter is too large, client player will drop packets, resulting in decreased video quality.
Packet Delay (D)	The buffer time of clients is limited. If the delay is too large, packets are discarded, resulting in decreased video quality.
Bandwidth(B)	Network videos have high real-time requirements and the cache of client is very small. When available bandwidth is less than the video streaming bit rate, the video image quality may be in serious decline.
Burst Level (D)	For wireless network instability, the burst level is introduced. If the users can not use network when they want to use it, user satisfaction will decrease.

Table II
EVALUATION OF QoE AND QoS

rating	good	fair	bad
Packet Delay	<150ms	150-200ms	>200ms
Packet Jitter	0-20ms	20-50ms	>50ms
Packet Loss	0-0.1%	0.1%-1%	>1%
MOS	5-4	3.5-4	<3.5

Table III
THE EXAMPLE OF NETWORK-RELATED QoS PARAMETERS AND ITS RELATIVE IMPORTANCE DEGREE OF VIDEO SERVICE

QoS parameters	Relative Importance Degree
Loss-L	41.5%
Burst-T	29.5%
Jitter-J	10.6%
Delay-D	9.6%
Bandwidth-B	8.8%

The normalized QoS value can be calculated through (1). In (1), the constant K is determined by the type of the access network. K is the determining factor in the quality of QoS. Depending on the type of access network (wired and wireless), this value is different.

$$QoS(X) = K \{L \times W_l + T \times W_t + J \times W_j + D \times W_d + B \times W_b + \dots\} \quad (1)$$

B. The QoS/QoE Correlation Model

Through the track of [11-13], we can create the empirical value that QoE rely on QoS. Fig. 1 depicts the relationship between them.

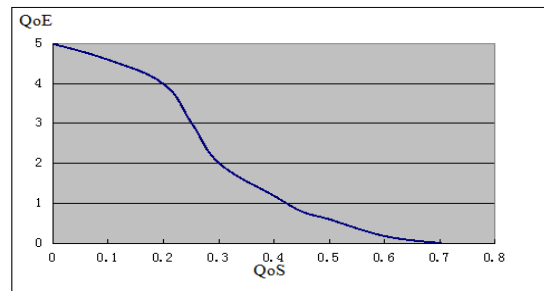


Fig. 1 The empirical value trend chart of QoS and QoE relationship

Based on the empirical value trend chart of QoS and QoE relationship, we decided to use the QoS and QoE mapping evaluation model proposed in [14]. But [14] did not verify this model sufficiently. In this paper, NS-2 [15] was used to simulate wireless network structure and the QoE values were calculated by using normalized QoS parameter values. The accuracy of the model was verified in systematic experiments. Model formula is as follows:

$$QoE = \alpha \times (1 - QoS(X))^{\frac{QoS(X) \times \beta}{\gamma}} \quad (2)$$

In (2), Q_r is a coefficient limiting the range of the video image QoE according to the display size and/or resolution of the terminal. Next, the $QoS(X)$ is the normalized value of quality level which is calculated by (2), and is determined by quality parameters of the network layer. The constant β expresses the subscribed service class. It means that QoE level which the premium service subscriber's request is high than the general service subscriber's in the network condition of the same QoS quality. Finally, γ reflecting the structure of the video frames according to the GoP (Group of Picture) length. The loss of an I-Frame more induces the poor quality than the other frames (P/B-Frame).

III. EXPERIMENTAL ENVIRONMENT

Most previous research in the industry used MPEG codec, but this paper will use the H.264 codec. The standard was formally known as advanced video coding in ISO / IEC [5]. H.264 video coding used the method based on hybrid encoding block. It has the advantages of all the previous encoder, and the coding efficiency of H.264 is higher than MPEG-4 and H.263 nearly 51%. Due to the layering concept was introduced in H.264 codec standard, so we use the encoding method has better network adaptability, which provides a better guarantee for real-time network video transmission.

Our video system evaluation program will use myEvalvid [15]. myEvalvid video quality evaluate system was proposed by Ke et al for MPEG-4, including video transmitter, assessment, video reconstruction, PSNR calculation and MOS subjective quality analysis, and it was linked by Trace files. But this paper adopts H.264 Evalvid evaluation system. Because the NS-2 itself does not have H.264 video transmission format, we need to add the appropriate packet header format. After the completion of the definition and the realization of the agreement, new agreements are added to NS-2, which includes modifying two files: one is Makefile, another is ns-default.tcl. Add myh264/myh264udp.o, myh264/myh264udpsink.o, and myh264/myh264trafficttrace.o to OBJ_CC in Makefile. And add Agent/myh264UDP set packetSize, Tracefile set debug to ns-default.tcl. After modifying agreements, the video can be encoded and decoded, and the basic preparation conditions of the experiment are completed.

The video transmission system we use is shown in fig. 2. The video sequence is encoded first, and then gets the trace file through the simulated network, and then decoded. NS-2 network simulator is used to simulate a wireless network. NS-2 is an event driven simulator, providing wide simulation support for related network protocols, such as TCP, UDP, etc., with wired and wireless networks, including local and satellite

networks[16]. QoS information is tracked using the trace file from both sending and receiving sides. Trace files are used to reconstruct the source image sequence and analyze the loss rate of the network, image transmission delay and jitter parameters. Finally, the decoder outputs the decoded YUV data.

Fig. 3 shows the network topology in which nodes $n_i, i=0\sim5$, are six wireless nodes, Agent set up on the sending node, n_4 . UDP client is built on the receiving node, n_5 . The receiver agent is set to null, so that the received data packets won't be processed. A CBR link is established between n_4 and n_5 . The protocol of this link is UDP. CBR packet size is set to 512 bytes. Network simulation time is set to 10s.

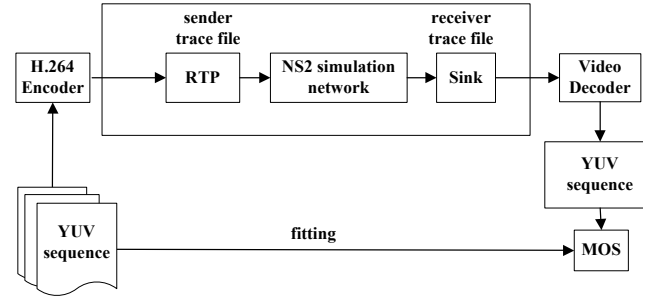


Fig. 2 framework of video transmission

The channel, the wireless communication, the network interface type and MAC layer protocols we used in simulation are wireless network transmission channel, radio wave propagation model, radio channel model and 802.11 protocols. RED (Random Early Detection) is used in our experiment. The priority scheduling scheme in the application layer is based on the type of video frames. Different frame types (I, P and B) have different priorities. I-frame has the highest priority. RTP packet format is generated by performing analysis on the H.264 encoder, and writes the packet information to the trace file.

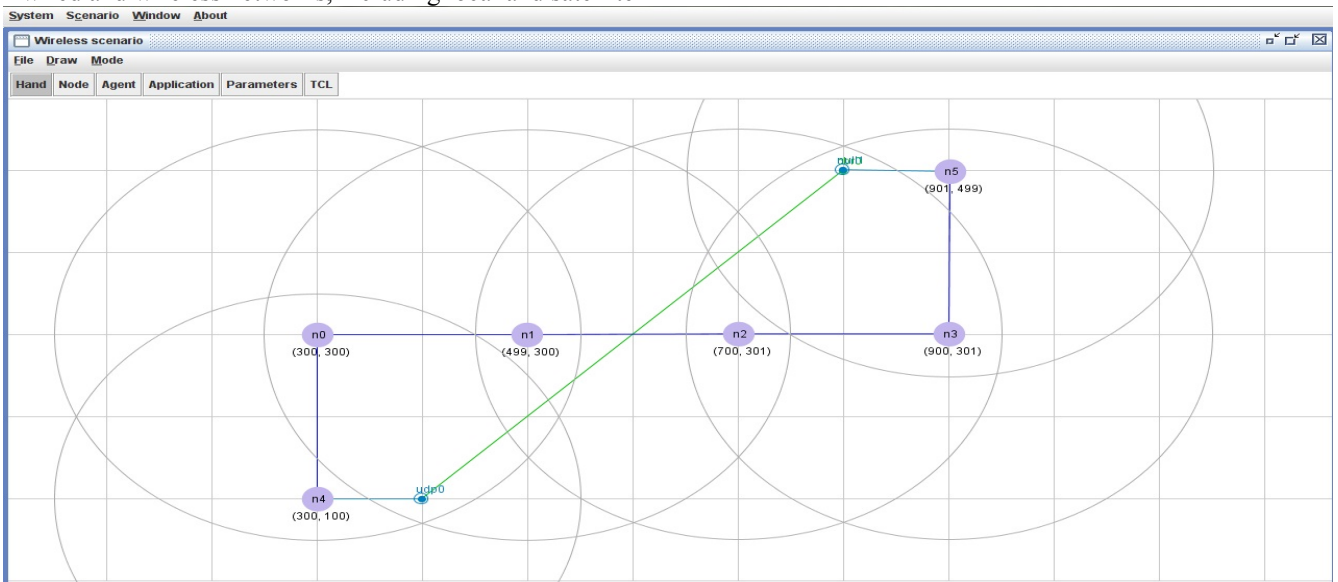


Fig. 3 network topology

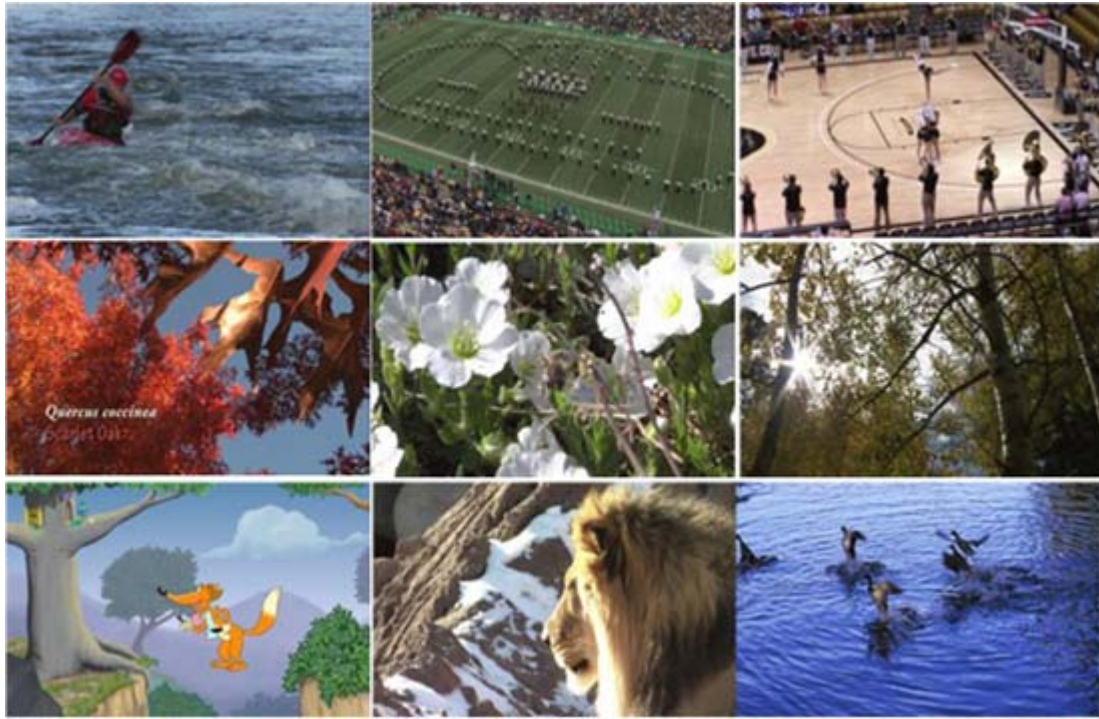


Fig.4 HD video reference sequence

TableIV
WEIGHTS OF QoS PARAMETER

Service	Parameter	Scope	Weight
H.264 HD video	Packets loss (41.5%)	1.28E-06	8E+04
		1.24E-06	8E+04
		1.22E-06	8E+04
	Burst Level (29.5%)	1.65ms	10
		0.64ms	10
		<0.63ms	10
	Packet Jitter (10.6%)	<50ms	0
		≥ 50 ms	1
	Packet Delay (9.6%)	100ms	0
		≥100ms	0.5
Bandwidth (8.8%)	8	2.0E-10	
	10	1.8E-10	
	≥12	0	

Table V
QoE VALUES OF FIVE INSTANCE VIDEOS AND
SUBJECTIVE MOS VALUES

X	QoS(X)	QoE	MOS
1	0.26826	3.04617	3.24166
2	0.13249	3.99721	3.79176
3	0.30635	2.78101	2.90833
4	0.07962	4.40193	4.64166
5	0.09758	4.24475	4.09166
6	0.15333	3.76514	3.96666
7	0.20134	3.07569	2.84176
8	0.08341	4.32112	4.00833
9	0.05217	4.67818	4.56666

The selected video sources are HD video sources [17]. There are six high-definition video source database, respectively vqeghd1, vqeghd2, vqeghd3, vqeghd4, vqeghd5 and vqeghd6. The contents of the sequences include: movies and movie trailers; Sports; music videos; advertising;

animation; broadcast news; general television material (e.g. documents, television programs).

Screen shots of typical HD video sources are such as fig.4. The first three are strenuous exercises for humans and the content complexity is high; among three videos are scenery, and content complexity is low; last three videos are animals, and video complexity is medium. All video playback duration is 10 seconds. The video display format is 1080p, frame rate 25, 29.97, 30 fps, bit rate 8, 10, 20 Mbps.

IV. SIMULATION RESULTS AND PERFORMANCE ANALYSIS

According to the relative importance of the QoS parameters in Table 5, calculate QoS weights of parameter on affecting Quality of Experience.

QoS parameters' values in Table VI were obtained through experiment. Their weights are gotten according to Table IV, and then calculate the value of QoS. All the value of α is 5. At last calculate the value of QoE and compare to the MOS value recommended by the VQEG. Comparison specified in Table V. As can be seen from the table, under the same conditions, the greater the packet loss rate the poorer the video quality; the larger the bandwidth, the better the video quality; the shorter the GoP, the better the video quality. Obtained QoE and subjective MOS value have an approximately linear relationship. A correlation coefficient of 93.5% is obtained by the test sequence proof that the high accuracy evaluation of QoS and QoE mapping model applied in this paper. Next we will validate the accuracy of our model by six databases from a qualitative and quantitative point of view.

Using DMOS values from VQEG and objective DMOS score we evaluated in the experimental simulation conduct a nonlinear fitting. We evaluate the performance of the model by four quantitative indicators, including nonlinear regression

correlation coefficients, Spearman correlation coefficients and root mean square error.

Table VI
VALUES AND WEIGHT OF THE VIDEO QoS PARAMETERS

No	Packetloss (W_1)	Packet Jitter (W_2)	Packet Delay (W_3)	Burst Level (W_4)	Bandwidth (W_5)	GOP Length
1	2.78E-06 (8.0E+04)	37ms (0)	105ms (0.5)	1.67ms (10)	8Mbps (2.0E-10)	9
2	2.24E-06 (8.0E+04)	39ms (0)	110ms (0.5)	1.05ms (10)	10Mbps (1.8E-10)	12
3	3.26E-06 (8.0E+04)	50ms (1)	100ms (0.5)	1.36ms (10)	8Mbps (2.0E-10)	15
4	1.58E-06 (8.0E+04)	30ms (0)	90ms (0)	1.60ms (10)	8Mbps (2.0E-10)	9
5	2.49E-06 (8.0E+04)	33ms (0)	100ms (0.5)	1.67ms (10)	8Mbps (2.0E-10)	12
6	2.65E-06 (8.0E+04)	35ms (0)	108ms (0.5)	0.65ms (10)	8Mbps (2.0E-10)	15
7	2.68E-06 (8.0E+04)	37ms (0)	105ms (0.5)	0.63ms (10)	8Mbps (2.0E-10)	9
8	1.96E-06 (8.0E+04)	40ms (0)	110ms (0.5)	1.68ms (10)	10Mbps (1.8E-10)	12
9	1.45E-06 (8.0E+04)	39ms (0)	105ms (0.5)	1.71ms (10)	20Mbps (0)	15

Table VII
TEST RESULTS

Assessment metrics	NLCC	SROCC	RMSE	OR
vqeghd 1	0.925	0.926	0.111	0.195
vqeghd 2	0.915	0.916	0.206	0.156
vqeghd 3	0.906	0.908	0.095	0.065
vqeghd 4	0.933	0.938	0.201	0.203
vqeghd 5	0.945	0.955	0.082	0.085
vqeghd 6	0.929	0.928	0.103	0.105
average	0.9255	0.9285	0.133	0.134

Fig.5 is a scatter plot of the objective score and DMOS value of all the videos (where in the dashed line represents the fitted curve of the Validation sequence and the test sequences, the solid line represents the fitted curve of all the video sequences), a high degree of aggregation in the figure indicate the model has a good consistency of the subjective and objective quality evaluation. Table VII shows the quantitative analysis of the video sequences, OR mean is 0.134, RMSE is 0.133, the SROCC and NLCC correlation coefficient are both greater than 0.925. The SROCC values of PSNR and SSIM are 0.634 and 0.815, respectively. QoS and QoE correlation coefficient in [1] is up to 0.90. From the analysis above, indicate that the model we applied has a good performance.

V. CONCLUSIONS

In this paper, a no-reference QoE evaluation model is used to achieve the calculated QoE value, evaluation the quality of the user experience with normalized QoS parameters. First, we set up a video transmission system in a wireless network simulation environment for H.264 video stream. According to

the different complexity and video service class, a priority transmission control mechanism is used. Use NS-2 to simulate the entire network environment, including packet loss, jitter and delay of the wireless network environment. Then the accuracy of the model is verified through different test sequences. Then use the video evaluation system myEvalvid to analyze the performance of the network, including packet loss, delay, jitter, bandwidth and GOP etc. Finally, we get the mapping model can efficiently satisfy the needs of real-time video transmission. In HD video services, these experiment conclusions may base on different video QoE requirements to help optimize bandwidth allocation, saving network resources and be able to predict high-definition video QoE based on QoS parameters. Experimental results have definite significance for high-definition video transmission.

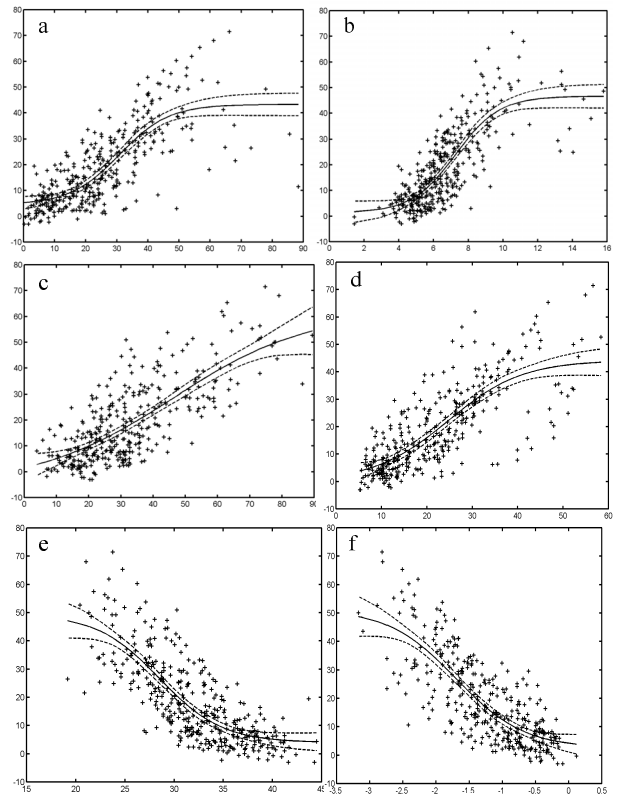


Fig.5 6 databases (a movie, b sports, c music videos, d animation, e news, f general television) scatter plot of subjective and objective score (abscissa represents the model output DMOS value, the vertical axis represents the average DMOS value, three lines represent the non-linear curve fitting)

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