Analysis of Streaming Service Quality Using Data Analytics of Network Parameters

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Abstract**—Quality of multimedia streaming service depends on network parameters such as bandwidth, delay, jitter and packet loss rate. In order to effectively improve the Quality of Service (QoS), it is needed to know which parameter is dominant in deterioration of the service quality at the moment. In the paper, we investigate the interdependency among network parameters in terms of finding out which parameter is dominant in the quality deterioration. We also studied the sensitivity of parameters on the change of quality in an emulated communication network. For these purposes, we performed experimental tests on streaming video with 16 testers, and we used transformed 5-level values for each network parameter to imitate a Likert style evaluation for each variable. It is found that bandwidth and delay affect more on service quality than jitter or loss rate.**

Keywords-Data analytics; Network parameter; Quality of Service; Streaming service

I. Introduction

During the last decades, quality management of real-time communications has been widely studied in order to provide improved multimedia services [1] [2]. With rapid development in audio-visual technology and products, various types of TV-based multimedia services have been introduced including high definition TV (HDTV). Recently, along with the wide spread of high speed cellular networks and wireless LANs, mobile multimedia services also became common for the tablet PC or Smartphone users. The increased wireless multimedia service is known as the key source of network traffic and service dissatisfaction [3] [4] [5].

The purpose QoS control in network service is to satisfy users. To satisfy the users, we should consider many factors simultaneously such as contents searching time, download speed, screen size, and contents itself, beside the network parameters such as bandwidth, delay, error rate or jitter. However we cannot satisfy all the resources simultaneously, so it is needed to prioritize factors to support. For example, we may choose large screen for some movies, high bandwidth for high quality image, and low jitter for conversations. For a given quality level, we need to choose optimal combination of network resources.

In the paper, we analyze simulation test data in order to find which network parameter dominantly affected service quality at the moment. In other words, we want to understand the relationship between quality factors in streaming service. However, it is difficult to take into account various network parameters and human factors together in the analysis because it is difficult to extract correct relationship between user satisfaction and the factor such as screen size, search time, download speed exactly. Therefore, in the paper, we considered only four typical network parameters (bandwidth, delay, jitter, and loss rate). As a further study, we can extend the number of factors in the dependency analysis following the rationale proposed in the paper.

The paper is organized as follows. Chapter 2 introduces related works for QoS studies. Chapter 3 describes an experiment for QoS related user experiment and result analysis follows on chapter 4. Chapter 5 is for conclusion and further works.

II. Related works

QoS measurement for multimedia services has been widely studied to find an optimized network environment [6]. Kostas E. Psannis, Yutaka Ishibashi and Marios G. Hadjinicolaou presented an approach for multimedia streaming services, which used priority including dedicated bandwidth, controlled jitter for video interactive services that require additional resources to provide differently encoded video [7]. The research showed how the encoded bit rate and its bandwidth give influence to the video quality. Liuming Lu, Xiaoyuan Lu, Jin Li monitored stream video quality by observing packet losses, and showed how the packet loss ratio affects the quality of video streaming services [8].

Most typical network parameters used in the QoS analysis are bandwidth, delay, loss rate and jitter [6]. Bandwidth is the most significant parameter in multimedia streaming service, delay can cause unsynchronized video/audio frames, packet loss would be the reason of video error, and jitter may cause frame bursting. However, it is rarely studied to consider the parameters together in order to find their dependencies. In the paper, we focused on finding the relative importance of the four parameters in streaming service.

III. Simulation Model

In the paper, we measured the quality levels for video streaming service via simulation. The simulation model is composed of three parts: the streaming server, network simulator and client PC. Figure 1 shows the simulation model used in the paper.

A. The streaming server

The streaming server provides video contents. A standard HD (1280x720 resolutions with 30 frames per second) video is sent to the clients through a simulated network.

 ISBN: 978-1-61208-242-4

B. The Network simulator

The Network simulator is used to emulate a real network. We used simulation package Shunra Cloud [9]. The package can change the bandwidth, delay, loss rate and jitter via software settings. We can choose any value of network parameters. For example, we can modify the channel capacity to have any bit rate, e.g., 10Mbps or 7Mbps. If the server is transmitting a 9Mbps video stream, the 10Mbps channel would be enough. However, if the bandwidth is set to be 7Mbps, then it will suffer a shortage of bandwidth. In simulation, we used various channel speed (bandwidth) ranging from, for example, 5Mbps to 10Mbps, and monitored the video quality with different bandwidth settings.

We also can choose any value for delay, loss rate and jitter for network emulation. With this scheme, we can have infinite number of sets for combinations (b, d, j, l) where b, d, j and l represent specific value of bandwidth, delay, jitter and loss rate respectively. In order to investigate the effect of each parameter to the video quality with a finite number of simulations, we need to minimize the number of parameter set. For this purpose, we chose discrete values for each b, d, j, and l.

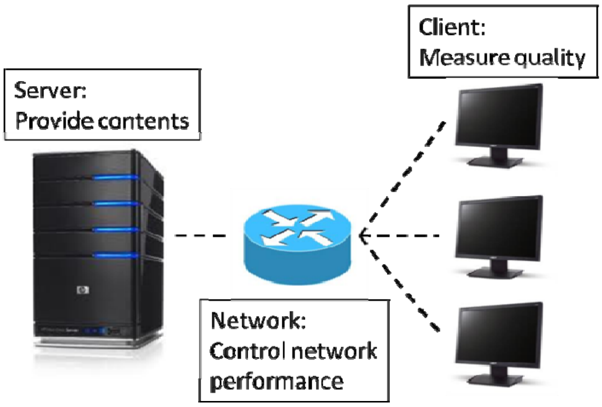

Figure 1. Simulation model.

In order to choose a reasonable finite number of parameter sets, we divided the range of each parameter into 5 quality levels (mimicking the Likert levels). For example, for the bandwidth parameter, first we set other parameter to have best conditions, that is, no delay, no error, and no jitter. Then we decrease the channel capacity (bandwidth) from 10Mbps down smoothly to find the Mean Opinion Score (MOS) evaluation to be 4 from 16 testers. Table 1 shows the 5 MOS threshold values for bandwidth, delay, loss rate and jitter. In the first column, when bandwidth is over 8.06Mbps, many people evaluated MOS 5, and with bandwidth of 7.85~8.06Mbps, many people evaluated the MOS to be 4, and so on. Below 7.47Mbps, many people evaluate MOS to be 1. In the evaluation we used the MOS such as, 5: Best, 4: Good, 3: Moderate, 2: Bad, 1: Worst.

TABLE I. LEVELS OF NETWORK PARAMETERS FOR EXPERIMENT

Likert	Bandwidth(Mbps)	Delay(ms)	Loss(%)	Jitter(ms)
5	8.06~	~257	~0.11	~28
4	7.85~8.06	257~359	0.11~0.15	28~55
3	7.75~7.85	359~423	0.15~0.17	55~140
2	7.47~7.75	423~455	0.17~0.21	140~188
1	~7.47	455~	0.21~	188~

Along the same way, we chose 5 discrete regions of delay, jitter and loss rate (see Table 1). Among the 5 classes of parameter levels, we used only 4 levels in simulation because any level-1 value of each parameter always generated intolerable video quality.

We then have in total 4(parameter) ^ 4(level) = 256 combination sets (b, d, j, l) to measure the effects of each parameter sets to the quality of service at the moment.

C. Client PC

At the client PC, testers evaluated the streaming video quality. In the simulation, we used a simple binary quality measurement that only evaluates the quality as “Good” or “Bad” [10] in order to find out the percentile of dissatisfaction of users, or “unacceptability rate”. For example, if one tester out of the 16 testers notified “Bad”, the unacceptability rate is 1/16= 6.25% at the moment. If two people showed “Bad”, then the unacceptability rate becomes 2/16=12.5%

IV. SIMULATION RESULTS

Figures 2-5 show the simulation result, where X axis represents the unacceptability rate evaluated by the 16 testers. Y axis denotes the probability of occurrence of network parameters (b, d, j, l) for different quality levels; i.e., b5 is a typical value of bandwidth for Best (e.g., over 8.06Mbps), b4 for Good (e.g. 7.85~8.06Mbps), b3 for Moderate, and b2 for Bad.

For example, in Figure 2, at unacceptability rate 6.25% (at the most left-hand side), b5 occurred 3 times out of four tests (3/4=0.75), and b4 occurred once (1/4=0.25). Y axis denotes the probability of occurrence of bandwidth levels, and X axis denotes the unacceptability rate, where TL (Trend Line) is approximation plot of the dots. Here unacceptability rate 6.25% means a good quality because only one tester out of 16 felt Bad quality, and 15 felt Good. When the video is in good quality (i.e., when low unacceptability rate in X axis), there is no low level of bandwidth (b2) cases (in Figure 2, the “x” marks the presence of b2). As long as the video quality is decreasing (i.e., unacceptability rate increase in the X axis), we can find more occurrence of b2 (see the trend line “TL-b2” in Figure 2 is increasing along with the X axis). When the unacceptability rate increases, we can find low occurrence of b5 (see the trend line ‘TL-b5” is decreasing in Figure 2). This represents that video quality is strongly dependent on the bandwidth levels in the various combination set of (b, d, j, l).

Figure 3 shows the dependency of delay levels (d5~d2) on the video quality. Y axis denotes the probability of delay and X axis denotes the unacceptability rate. In Figure 3, we can find strong dependency of delay on the video quality because as the unacceptability rate increase, the TL-d5 de-

 ISBN: 978-1-61208-242-4

creases down and the TL-d2 increase up sharply. We can find Figure 3 shows similar pattern to Figure 2, which means that delay affects the video quality in a similar manner like bandwidth. It is noted that the levels (b5~b2) or (d5~d2) were determined from a level normalization process as summarized in table 1.

Dependency of jitter and loss on the video quality are shown in Figures 4 and 5, respectively. From Figures 4 and 5, it is shown that jitter and loss did not affect much on the video quality. It can be said that jitter is less sensitive to the quality of video comparing to the bandwidth or delay.

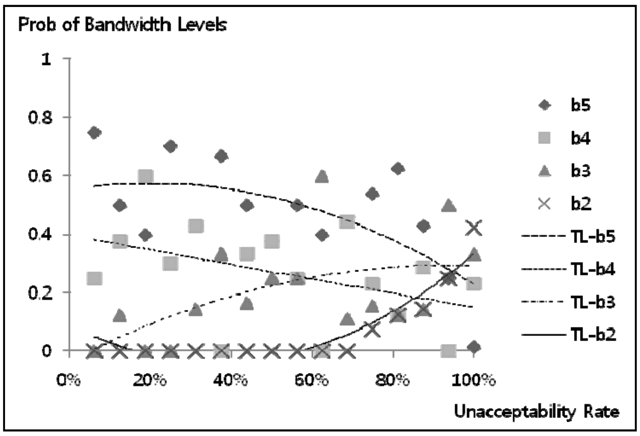

Figure 2. Dependency of bandwidth levels (b5~b2) on the video quality. Y axis denotes the probability of bandwidth levels, and X axis denotes the unacceptability rate, where TL (Trend Line) is approximation plot of the dots.

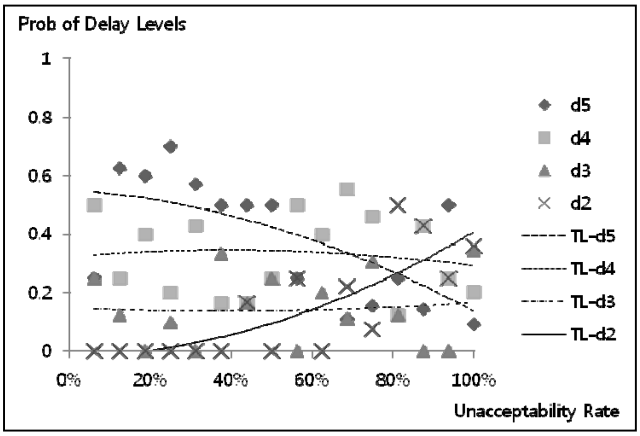

Figure 3. Dependency of delay levels (d5~d2) on the video quality. Y axis denotes the probability of delay levels, and X axis denotes the unacceptability rate, where TL (Trend Line) is approximation plot of the dots.

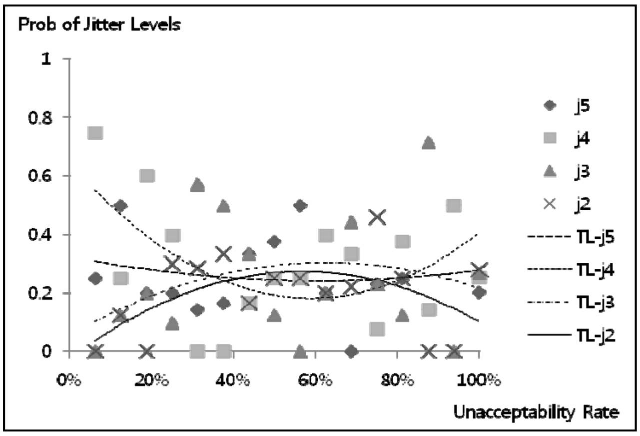

Figure 4. Dependency of jitter levels (j5~j2) on the video quality. Y axis denotes the probability of jitter levels, and X axis denotes the unacceptability rate, where TL (Trend Line) is approximation plot of the dots.

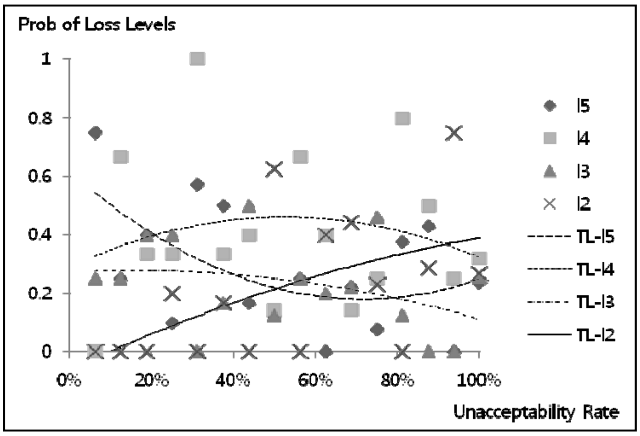

Figure 5. Dependency of loss levels (l5~l2) on the video quality. Y axis denotes the probability of loss levels, and X axis denotes the unacceptability rate, where TL (Trend Line) is approximation plot of the dots.

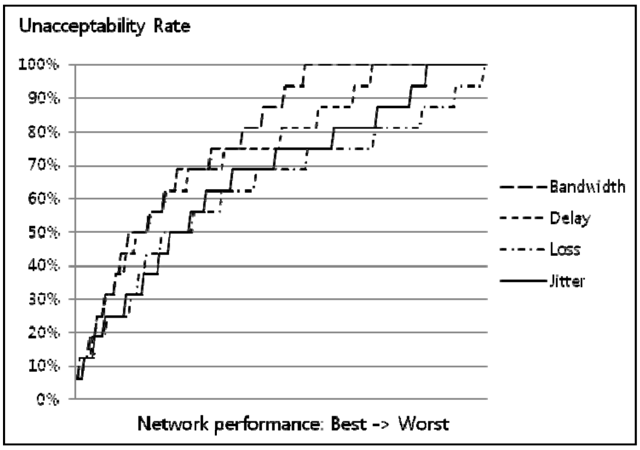

Figure 6. Comparison of the sensitivity of (b, d, j, l) to the quality variation (unacceptability rates).

 ISBN: 978-1-61208-242-4

Figure 6 compares the sensitivity of (b, d, j, l) to the quality variation (unacceptability rates). In Figure 6, the X axis shows the number of experiment cases under the assumption of that the distribution of each level of parameter is even. In other words, under the same distribution of parameter values, we can see that as the video quality is decreasing (going right in the X axis) the bandwidth gives more influence (i.e., sensitive) to the quality comparing to other parameters. The next sensitive parameter is delay and the next one is jitter.

V. CONCLUSION AND FURTHER WORKS

In the paper, we compared the influence of network parameters to the quality of streaming video. In order to perform the simulation within a finite number of tests, and compare them with evenly distributed patterns, we used a discrete set of levels for each parameter: bandwidth, delay, jitter and loss. Level 5 is Best quality, and level 4 is Good, level 3 is Moderate, and Level 2 is Bad. We found that bandwidth and delay affected directly the quality of video rather than the jitter or loss rate. We compared the dependency and sensitivity of the parameters on the service quality.

Even though the simulation was performed by 16 testers, and only 256 combination of parameter set are used in this paper, a larger dataset from real communication network service will provide a more accurate analysis.

ACKNOWLEDGMENT

This research was supported by the MKE (The Ministry of Knowledge Economy), Korea, under the ITRC (Information Technology Research Center) support program supervised by the NIPA (National IT Industry Promotion Agency) (NIPA-2012-H0301-12-1004)

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