An Identification of Correlation between Network QoS and Video Quality Index for IPTV Service

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Abstract — Importance of perceptual quality has arisen as one of the major issues to successfully deploy IPTV services. Therefore, guaranteeing a certain level of network QoS is well and widely understood, but it is much more important to notice perceptual quality as perceived by the user. In this paper, we seek to identify relationship between video quality index and network QoS parameters so that we can ultimately figure out video QoE assessments with network QoS for IPTV service. We conduct simulations for seeking the impact of networking events on perceptual quality and how the events are correlated with video artifacts.

Keywords — IPTV service, perceptual quality, QoE, QoS, video impairment.

1. Introduction

With convergence of voice, video, and data services, IPTV is getting toward a major killer deployment for broadband network which represents a new paradigm for the next generation network. The network evolution which leads the speed of transmission rate from only 1 Mbps at the early startup to more than 100 Mbps for now by adoption of recent technologies such as optical accesses, higher-speed DSLs, cable modems, now needs more wide-range killer application. In this prospective IPTV is the quite suitable model for delivering TPS (Triple Play Service) or QPS (Quad Play Service) for advance. However, to successfully lead IPTV service, there exist several technical barrier issues that should be considered. Resource allocation is one of the high level requirements related for service provision. Traditionally most of existed decisions have focused on QoS specific ways which network providers usually have concerned. However, the importance of perceived quality is getting bigger and also for the subscribers’ prospective, the most important quality is the perception quality which is also known as QoE (Quality of Experience). QoE is the quality index and should be provided to go down the line for IPTV service. However, contrary to QoS (Quality of Service), this index is subjective and there exists no clear standard or consensus of the requirement. Therefore, to make a clear index system, the necessity of the estimation system which can objectively calculate QoE from network state is arisen. For majority of IPTV service QoE, video quality is key scheme for reveal the correlation system. With this point, we will identify the correlation and effect between network QoS parameters and video impairments.

In section 2, we introduce several study of IPTV service quality in global standard organizations. After that, the need for the video quality of study is discussed in Section 3. The tested environment is explained in Section 4. The experimental results are analyzed in Section 5. In the last section, conclusions and future works are presented.

2. IPTV Service Quality

According as the needs of IPTV service and completions between telecommunication companies have increased, the importance of SLA (Service Level Agreement) has also become one of the major issues to successfully deploy IPTV services. Especially, change of the broadcast trend from legacy services such as simple video stream or VoIP service to TPS (Triple Play Service) or QPS (Quad Play Service) makes that telcos should consider perceptual quality of subscribers for SLA decisions. Thus the development of service quality index for IPTV will be essential not over the long haul. In this section we introduce the standardization trends of IPTV service quality management for each organization.

2.1 ATIS

ATIS (Alliance for Telecommunications Industry Solutions) classifies IPTV QoS/QoE factors like Fig. 1. QoE assessments are related with QoS factors and accordingly, IPTV QoS is categorized into 2 layers: Application QoS, Network QoS.

![Figure 1. Factors impact on QoS and QoE](image_url)

Application QoS layer represents performance of applications and network QoS layer represents performance of delivery networks. Furthermore, application QoS layer is divided into three sub layers according to its quality characteristics.
Therefore, ATIS has four IPTV quality layers and we can find quality metrics for each layer in Fig. 2 and table 1.

OoS Parameters

| Video & audio | Text & graphics |
| Media compression & synchronization | Network transmission |
| Network layer |

Table 1: ATIS IPTV Quality Metrics

<table>
<thead>
<tr>
<th>IPTV Quality Layer</th>
<th>Metric</th>
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</thead>
<tbody>
<tr>
<td>Transaction Quality</td>
<td>IGMP join/leave latency, channel change delay, DRM_error, service_availability_error, service_impairments_error</td>
</tr>
<tr>
<td>Content Quality</td>
<td>MOS-V, MOS-A, MOS-AV, per PID bandwidth, program/channel bandwidth, PCR jitter, PCR failures count, ITF buffer overruns/underruns, AV sync</td>
</tr>
<tr>
<td>Media Stream Quality</td>
<td>TS sync loss count, sync byte error count, continuity count error count, Packet identifier error count, Presentation time stamp error count</td>
</tr>
<tr>
<td>Transmission Quality</td>
<td>RTP packet loss rate before/after error correction, RTP packet discard rate, Out of sequence Packet rate, RTP burst rate before/after EC, Gap loss rate, RTP burst length before/after EC, Gap length, smoothing jitter, Peak packet to packet delay variation, RTP loss period count/loss distant count/minimum loss distance/maximum loss period, packet retransmissions</td>
</tr>
</tbody>
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Table 2: DSL Forum IPTV Quality Metrics

<table>
<thead>
<tr>
<th>Layer</th>
<th>Metric</th>
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<tbody>
<tr>
<td>Service Layer</td>
<td>Availability/Reliability/Survivability</td>
</tr>
<tr>
<td>Control Plane</td>
<td>Channel change speed and scalability with load, VoD Control, System start-up, EPG user interface navigation responsiveness</td>
</tr>
<tr>
<td>Data Plane</td>
<td>Bit rate/Resolution/Application layer video encoding, Encoder quality and settings, Preprocessing, Tandem encoding and rate shaping</td>
</tr>
<tr>
<td>Transport Layer</td>
<td>Control Plane</td>
</tr>
<tr>
<td>Data Plane</td>
<td>Loss, Delay, Jitter</td>
</tr>
</tbody>
</table>

Although each standarization organization has its own IPTV quality metrics, there doesn’t exist clearly revealed relationship between IPTV QoS and QoE. The following sections, we discuss main video factors that effects overall perceptual qualities and how we can develop the quality index system for IPTV QoS/QoE relationship.

3. Video Quality

There have been lots of progresses of video compression algorithms which grant widespread distribution of video and multimedia in digital form. Mainly, quality degradations are occurred by loss of compression and frame errors. Thus, to accurately measure video quality, subjective experiments have been studied in several procedures. The problem with subjective experiments is that they are time-consuming, hence expensive and often impractical. Furthermore, for many applications subjective experiments cannot be used at all. For these reasons, mean squared error (MSE) or peak signal-to-noise ratio (PSNR) like features are suggested for objective measurement. MSE, PSNR operate solely on the basis of pixel-wise differences and ignore the impact of video content. Given these limitations, establishing and maintaining we need to model the QoE level for the service with different applications, but as yet, the measurements and protocols have no direct relation to the video quality as perceived by the user[4].

3.1 Video Impairments Quality with MOS

To compensate shortages of the previous, we need to reveal the video quality index which can be said video MOS (Mean Opinion Score). Firstly, the relation between network parameters and video impairment need to be understood. That is, after the relation shows how the change of network condition affects corresponding video impairments (video quality indicator), the video MOS, the QoE index, can be modeled based on the acquired information. Fig. 4, relationship between quality indexes, shows network QoS parameters affect video quality indicator which is video impairments, and Video MOS is complex influenced by multiple impairments.
We conducted simulations at various packet error rates (PERs). System was tuned not to create packet drops. Each simulation for a given packet error rate was run for at least 10 times. We show the proportion of blockiness and blurriness compared to source video in Fig 6. Blockiness presents sharply with increasing PER. Contrary, blurriness grows smoothly. This happens due to a video compression. Because a few corrupt reference frame packets can affect decoding process, reconstruction of dependent frames is mattered. With higher error, increment of blockiness portion is relatively less. That is, at higher PERs, much unlike blockiness, blurriness increases.

Figure 6. Packet Loss/Error VS Blockiness

We seek to understand the correlations between network events like losses, jitter, delay and video quality metrics like blockiness, blurriness, and jitter. The environment used for simulations is shown in Fig 5.

4. Simulation Results

Simulations were performed to study the impact of network events for video quality index. We represent video quality in terms of blockiness and blurriness. We change the tunable parameter such as delay, jitter, loss at different rates to introduce various network events.

Figure 5. Testbed for simulation

More precisely speaking, we cannot map network QoS directly to video QoE. Therefore, to smooth this mapping process, we need intermediate index also known as video quality indicator.

The most common phenomena which can be appeared in the networks are delay, loss, and jitter. This kind of quality deterioration usually leads the impaired video signals and makes damaged video playout in the screen. The representative video impairments are blockiness and blurriness, frame freezing/skipping which simply can be seen in current internet video stream.

In [4], blockiness, also known as block distortion, can be caused by coarse quantization of the spatial frequency components of an image during encoding, and is due to the block structure of MPEG images (8 x 8) blocks of pixels. Video decoders may include a de-blocking filter to smooth edges between blocks shown in Fig 5. Blurriness is a reduction in the sharpness of edges, and will be more widely observed in lower bit rate or lower frame algorithms on video sequence with high rates of motion shown in Fig 6. Frame freezing/skipping is typically associated with low bit rate encoding of video sequences with motion. Motion that was originally smooth appears as stops/discontinuous jumps. For adaption of Video QoE index system, we should find out first the correlation between network QoS parameters and video quality indicator which is shown in Fig. 4.

3. Testbed Set-up

The testbed is set up of source videos, encoders/decoders, a simplified module with tunable parameters. We utilize both MPEG-4 and VC-1 specification to encode the source video stream. We test simulations that suit to model various network dynamics and compare the origin video with the impaired one. The performance procedures occur as the following sequence of events. First, we take a process which encodes the raw video contents with MPEG-4/VC-1 specification. After previous event, encoded frames are converted to IP packets. The packets are flowed to the linear system. At the linear system, we apply to tune the three network parameters (delay, loss, error) for those packets. Then, the destination receives IP packets and forms the MPEG-4/VC-1 frames with packets. At playout, frames are recorded in the new file system. We try to identify the correlations between network impairment like delay, loss, error and video quality indicators like blockiness, blurriness. Video is injected with constant rate so the packets are only affected by the tunable system of three network parameters. The linear system tunes to create various conditions with delay, loss, and error.
blurriness doesn’t rise sharply. Therefore we can reflect growing user dissatisfaction with increasing error rates.

Packet loss would occur a partly loss of a frame. Thus most of video algorithm has compensation functions in reconstruction of frames. We can observe that the packet losses affect blockiness more than blurriness in Fig. 6 and Fig. 7 because dependent frames are constructed with reference frames. In case of total frame loss, video metric can’t be compared so we simulated to cause proper congestion for the network to lose a streaming frame. The main differences in blurriness values for different PERs showed the effect of loss in blurriness is far less than the effect of a loss in blockiness.

We seek to understand the effects of increasing delay on blockiness and blurriness in Fig. 8. Notice that the difference between blockiness and blurriness are much smaller compared to packet loss/error cases. Therefore, in this experiment, delay makes little difference to the subject. However, if losses in combination with delay are introduced, there exist values changes which represent lower satisfaction. Note, however, that calculations are not calculated with the metric of expected frame at a particular time of playout. Hence, even if the video starts after a while from its generation event at the source, overall video quality is high provided there are little losses.

4. Conclusion

We begin to study the correlations between network QoS parameters and perceptual video streaming for IPTV services. We have gone further in establishing correlations between network events and perceptual video quality. We find loss is the most degrading factor because client doesn’t consider retransmission and not only packet loss problem but also packet error should be considered in service delivery for IPTV. The results for blockiness and blurriness represent that subjective measurement and perceptual quality are essential for video quality assessment.

This work was supported in part by MIC, Korea under the ITRC program(ITAC10008010036) supervised by IITA.

REFERENCES