Video Quality Measurements for Mobile Networks

Openwave Media Optimizer

Providing Best-in-Class Video with Superior Quality and User Experience

About Openwave

Openwave Systems Inc. (Nasdaq: OPWV) is a global software innovator delivering context-aware mediation and messaging solutions that enable communication service providers and the broader ecosystem to create and deliver smarter services.

Building on our mobile data heritage, Openwave mobilizes the internet with predictive solutions based on real-time analytics that mediate among all the different ecosystem elements and enhance every mode of IP traffic. The result is a 360-degree view of users, the network, devices and services that enable our customers to proactively optimize network resources, launch smart mobile services quickly, and provide a contextually relevant user experience. Openwave is a global company with a blue chip customer base spanning North America, Latin America, Australia and New Zealand, Asia, Africa, Europe, and the Middle East. Openwave is headquartered in Redwood City, California. For more information please visit www.openwave.com.

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Introduction

Media (video and audio) is a network-intensive application that consumes more wireless network bandwidth than other applications including email, P2P, gaming and website browsing.(Cisco, 2010). Optimizing delivery of video content is critical to managing network usage both during times of congestion and during normal operation. However, video optimization on a wireless network poses a different set of challenges than on a traditional wireline network. An intelligent and high-performance video optimization solution must manage real-time network congestion, constant variation in available bandwidth and changing user-browsing patterns.

Video optimization techniques must consider the quality of optimized videos. A complete solution should provide a network operator with dynamic choices in quality level driven by real-time network data traffic and the availability of network resources.

Quality can be measured both subjectively and objectively. The quality of optimized video depends on a number of factors, including the optimization technique applied, codec[1] and container[2], targeted device resolution, video profile, video bit rate and frames per second.

Optimization Techniques and Video Quality

Video optimization techniques have been around since the last decade but up to this point have mainly been used for wireline networks and television content delivery. Popular video optimization techniques used by wireless service providers include Constant Quantization Parameter (CQP) Constant Bit Rate (CBR) and Variable Bit Rate (VBR). CQP and CBR are relatively easy to enforce on a wireless network, but are less intelligent and provide a less than optimal user experience. CQP compresses every frame of a given type in a video by the same amount and does not take into account whether the video has high-motion content (like a football match) or not (like a newscast). In other words, this technique does not optimize based on video content. CBR refers to video or audio encoding where the bitrate used does not fluctuate. Many HD-quality videos have high bit rates that make them difficult to watch on a low-bandwidth wireless network. Using the CBR technique, the bit rate is throttled uniformly on all videos to a level acceptable for mobile users. This technique does not take into account the content type (sports, music, etc.) and blindly throttles the bit rate, again creating a less than optimal user experience.

The Content-Aware Compression (CAC) technique, a variation of the Variable Bit Rate technique (VBR),dynamically chooses the appropriate amount of bit rate reduction depending on motion components in the video. The human-eye perceives more detail in still objects than objects in motion. Because of this, content-aware compression can apply more compression (drop more detail) when things are moving, and apply less compression (retain more detail) when things are still. When employing the CAC technique, video will be perceived to be of higher quality.

Each of these optimization techniques can be applied to any given video irrespective of codec type, however, H.264 videos are generally better in quality and require fewer bits to encode than H.263[3]. In addition to codecs, video profiles[4]

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1 http://en.wikipedia.org/wiki/Video_codec

2 http://en.wikipedia.org/wiki/Container_format_%28digital%29

3 http://www.apple.com/quicktime/technologies/h264/faq.html

4 http://en.wikipedia.org/wiki/H.264/MPEG-4_AVC#Profiles

affect the video quality. The baseline video profile typically used in mobile videos and video conferencing modes offers a reduced user experience as compared to the main or high video profiles used for digital TV broadcasts and HD television programs. Employing compression techniques such as CBR, CQP and CAC can translate a high/main profile video to a baseline video during optimization and offer significant trade-off between quality and data-savings. Similarly, these optimization techniques can increase/decrease the video bit rate and frames per second of the optimized video. Higher bit rate and higher frame rate typically result in better quality videos.

Methods to Measure Quality

Irrespective of the optimization technique used, video quality has been traditionally measured either subjectively (human testing – A/B testing) or objectively (computerized algorithms).

Subjective video quality testing measures how a video is perceived by a viewer and designates the viewer's opinion on a particular video sequence. However, performing a subjective assessment of videos for wireless networks could be an ambitious project as the tests are quite expensive in terms of time (preparation and running) and human resources. Retesting could also be a required because of constantly evolving transmission protocols and mobile video standards.

Objective video-evaluation techniques are mathematical models that approximate the results of subjective quality assessments but are based on criteria and metrics that can be measured objectively and automatically evaluated by a computer program. The following sections briefly describe some of the popular objective quality measurement standards and their advantages/disadvantages:

Peak-Signal-to-Noise-Ratio (PSNR)

Peak-Signal-to-Noise Ratio (PSNR), or the equivalent mean-squared error (MSE), is a simple measure of image quality based on average error between the original and optimized video.

PSNR measures the fidelity (how similar a sequence is to the original one). Compared to other objective measures, PSNR is easy to compute and is well understood by most. However, the correlation to subjective quality measures is poor. PSNR considers only the luminance component and neglects the chrominance component, which is important to human perception.

Structural Similarity Index (SSIM)

SSIM is a more advanced measurement index than PSNR. PSNR measures errors between the original and optimized image; SSIM measures the structural distortion, luminance and contrast differences between the two images. The idea behind SSIM is that the human vision system is highly specialized in extracting structural information from the viewing field but is not specialized in extracting errors. Thus, a measurement on structural distortion should give a better correlation to the subjective impression. However, the mathematical complexity of this calculation is comparatively high and the SSIM calculations might vary from that of the subjective measurements. More tests are needed to fully verify the validity of this measurement on motion videos.

DCT-Based Video Quality Evaluation

Conventional video quality metrics (PSNR and SSIM) do not take into account the spatial and temporal properties of human visual perception. In 1998, A.B. Watson proposed a Discrete Cosine Transform (DCT) based Video Quality Metric (VQM) that exploits the property of visual perception (Watson). The first step in this method consists of various sampling, cropping and color transformations that serve to restrict processing to a region of interest and to express the sequences in a perceptual color space. The detailed description of this implementation is described in (Xiao, 2000)

Benefits of Video Quality Metrics

Video Quality Metric (VQM) software tools provide both standardized methods (i.e., ANSI T1.801.03-2003, ITU-R Recommendation BT.1683, and ITU-T Recommendation J.144) and non-standardized methods (i.e., expanded) for measuring the video quality of digital video systems. These systems include direct broadcast satellites (DBS), standard definition television (SDTV), high definition television (HDTV), video teleconferencing (VTC) and wireless or IP-based video streaming systems.

VQM was developed by the Institute of Telecommunication Sciences (ITS) to provide an objective measurement for perceived video quality. VQM measures the perceptual effects of video impairments including blurring, jerky/unnatural motion, global noise, block distortion and color distortion and combines them into a single metric. Test results show that VQM has a high correlation (0.95) with subjective video quality assessment and has been adopted by ANSI as an objective video quality standard[5].

Openwave Media Optimizer

Openwave's Media Optimizer uses a Content-Aware Compression (CAC) engine to analyze the motion content in videos and then applies the appropriate compression algorithm. This results in far superior quality videos as compared to the traditional compression techniques used by the rest of the market. Moreover, the CAC engine offers multiple levels of optimization, including Low, Medium and High, with a corresponding quality level measured using VQM.

VQM compares the original video frame-by-frame with the optimized video and provides an average value for all the frames in a given video.Lower VQM values are considered to have better subjective video quality. A VQM value of zero implies that the original and optimized frames are identical.

Figure 1 demonstrates Openwave Media Optimizer's optimization levels using a sample video from www.ferrari.com.In this example, the CAC identifies that the focus of the video is the automobile and renders that object as close as possible to the original. Optimization efforts are focused on the surrounding areas such as the road and pavement. For the subscriber consuming this optimized video, the visual impact and the user-experience are retained; for the network operator, data-transport costs are reduced.

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[5] http://www.its.bldrdoc.gov/n3/video/VQM_software_description.php

Original video

File size: 11.2 MB
Duration: 1.53 minutes
Codec : Advanced Video Codec
Container: Flash

Openwave Optimization Level – Low

File size: 6.59 MB
Duration: 1.53 minutes
Codec : Advanced Video Codec
Container: Flash
Compression rate: 41%
VQM: 0.83359

Openwave Optimization Level – Medium

File size: 5.14 MB
Duration: 1.53 minutes
Codec : Advanced Video Codec
Container: Flash
Compression rate: 54%
VQM: 0.99806

Openwave Optimization Level – High

File size: 3.94 MB
Duration: 1.53 minutes
Codec : Advanced Video Codec
Container: Flash
Compression rate: 66%
VQM: 1.23643

Figure 1 - Sample video optimization levels using Openwave's Media Optimizer

Results of Openwave VQM Measurements

Figure 1shows a specific example of the CAC engine in action. To better measure the quality of Openwave’s CAC technique, larger samples of videos were also subjected to VQM-based quality measurements. The Top 50 YouTube.com videos were optimized using low, medium and high settings. These videos were chosen from 5 categories (Sports, Auto, Music, How To and News). These categories represent videos with varying motion content that were popular (most viewed) during the month of May 2010. The results of this test are summarized in Table 1 and graphically represented in Figure 2 and Figure 3.

	Data-Volume (in MB)				Compression Rate			VQM		
	Original	Low	Med	High	Low	Med	High	Low	Med	High
Auto	190.3	131.0	98.7	71.58	31.2%	48.2%	62.4%	1.0	1.3	1.6
HowTo	99.9	61.4	47.1	35.13	38.5%	52.9%	64.8%	0.8	1.0	1.2
Music	164.7	117.0	93.5	71.73	28.9%	43.2%	56.4%	1.2	1.4	1.8
News	89.4	55.2	42.0	31.29	38.3%	53.0%	65.0%	1.7	1.9	2.2
Sports	95.0	82.6	63.6	46.98	13.1%	33.0%	50.6%	2.3	2.5	2.8
	639.3	**447.1**	**344.9**	**256.7**	30.1%	46.1%	59.8%	**1.4**	**1.6**	**1.9**

Table 1 Compression rate vs. quality measurement

Table 1 shows the total data volume in MB of downloaded videos from YouTube.com when using the respective optimization levels of Openwave Media Optimizer. A comparsion among the optimization levels shows the original data volume in MB vs. the data volume at low, medium and high compression levels. Data savings at high compression levels is shown to be greater than at medium or low compression levels.

There is avariation in the compression rate within the low, medium and high columns. This is because each category of video has varying levels of motion content that the CAC engine takes into account during optimization. For example, news video shows higher compression rates than sports videos because news contains fewer motion components than sports.

Each video in the 5 chosen categories was compared against the original and the quality measured and averaged using VQM. This is tabulated in the VQMcolumns. Lower VQM numbers typically represent better quality videos.Lower compression rate videos demonstrate better VQM quality numbers as compared to medium and high compression.

Figure 2 shows the overall data volume (in MBs) of the original 50 videos and compares it against the low, medium and high optimization settings. On average these settings provide a compression rate of 30.1%, 46.1% and 59.8% respectively.

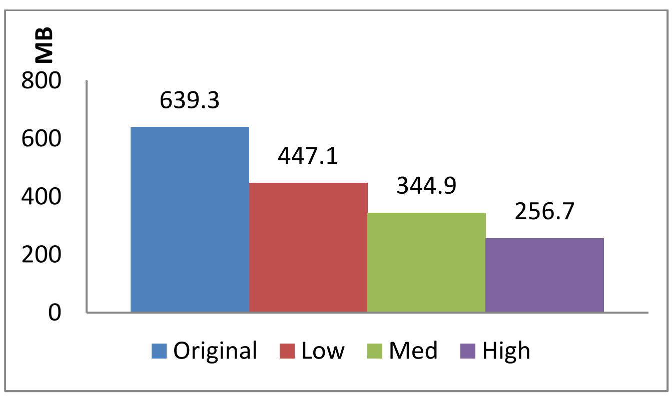

Figure 2 Comparison of data savings for Top 50 videos from YouTube.com based on Original, Low, Medium and High optimization settings with Openwave Media Optimizer

Figure 3 represents the average VQM values for low, medium and high optimization settings. These values compare each optimized video with its original version and average the value for the entire sample.

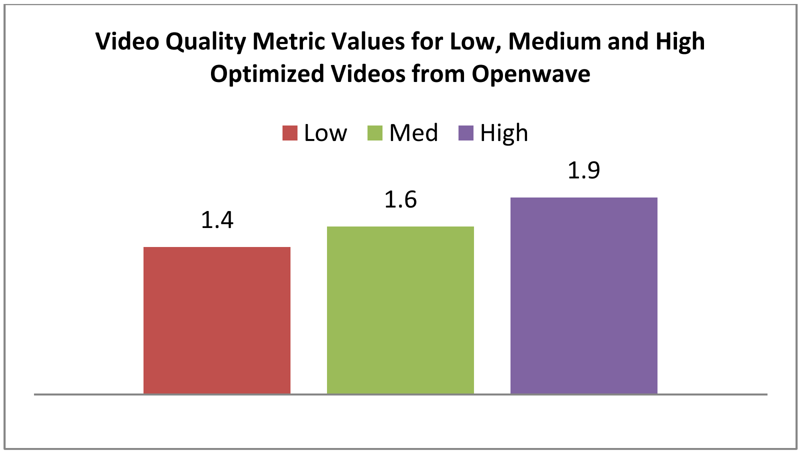

Figure 3: Quantifying video quality with varying optimization settings

Conclusion

There are several techniques to optimize videos and to measure their quality. Each technique has its pros and cons. Video quality measurement techniques for wireless networks are still nascent and lack a single standard, which makes its challenging for optimization vendors. However, quantifying optimized video quality is extremely beneficial for wireless network operators as it provides intelligence to manage network usage. Openwave Media Optimizer's compression engine applies best-in-class optimization techniques that are not only network-aware but also content- and quality-aware. Results indicate that Openwave's content-aware compression techniques provide better quality videos, even at higher compression ratios. Openwave's optimization techniques provide a transparent trade-off between video quality and compression levels. Using VQM as a standard for measuring subjective video quality establishes Openwave's Media Optimizer as the industry-leading solution for video optimization.

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