A New Quality-Oriented Adaptation Scheme for Video-on-Demand

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A new Quality-Oriented Adaptation Scheme (QOAS) is proposed in which the adaptation of streamed video is based on end-user perceived quality information. QOAS has been tested in a simulated local multi-service IP network with various types, sizes and shapes of background traffic. Test results show good end-user perceived quality and high link utilisation with very low loss rates. In addition, the performance of QOAS is very close to that of an ideal adaptive system in all traffic conditions.

Introduction: The QOAS system proposed in [1, 2] is used for MPEG2 Video-on-Demand (VoD) delivery in local multi-service IP networks. QOAS balances the need for high end-user quality with increased network utilisation, regardless of the nature of other cross traffic. A high utilisation would allow an increased number of customers to be served from a limited infrastructure, minimising the costs, but decreasing the end-user quality. QOAS's goal is to maximise end-user perceived quality and links' utilisation in the existing network conditions.

QOAS varies the transmitted ***quantity*** of video data by dynamically adjusting the ***quality*** of the streamed video. In comparison with other approaches [3], its novelty is that these adjustments are done based on client-computed **quality scores** that describe the current quality of delivery sent via regular feedback. These scores include **short-term** and **long-term** assessments of both the **end-user perceived video quality** [1] and **IP performance parameters** (e.g. delay, jitter, loss rate). During transmission the video quality is varied in a controlled manner according to the feedback reports. It requires fewer negative quality scores to trigger a quality decrease than positive for an increase. This ensures a fast reaction during bad delivery conditions helping to eliminate their cause and makes sure that quality upgrades are performed only after the network conditions have improved.

Simulation Test Results: The QOAS system has been implemented by a simulation model using Network Simulator version 2 (NS-2), which was used to test the performance of QOAS in controlled conditions with different types of background traffic. QOAS performance was compared to that of an (impractical) *ideal adaptive scheme* that achieves 0% loss and 100% bottleneck link utilisation, while maximising the end-user perceived quality by using all the spare bandwidth under the given transmission conditions. End-user perceived video quality under both adaptation schemes was determined using the Q metric [4] and was measured on the ITU-T five point scale [5].

Five possible quality states were defined in the server adaptation space of the QOAS simulation model. Multimedia sequences with different motion content were MPEG2 encoded at five average bitrates (2.0 Mb/s, 2.5 Mb/s, 3.0 Mb/s, 3.5 Mb/s and 4.0 Mb/s), using the same frame rate (25 frames/s) and the same 9-frame IBBP pattern. Video traces were collected and each one was assigned to one of these pre-defined server quality states. This process was repeated for each multimedia stream. A simple "Dumbbell" topology with bottleneck's bandwidth set to 100 Mb/s and link delay set to 0.1 s was used during simulations. The bottleneck link buffering used a drop-tail queue of length proportional with the product between the round trip time and the bandwidth.

Different types of background traffic commonly found in IP-based networks (see Table 1) with various shapes and sizes were generated using NS-2. UDP (constant bitrate - CBR and variable bitrate - VBR) and TCP (FTP and WWW) traffic were considered on top of a large amount of CBR traffic that corresponds to a well multiplexed load.

The test results presented in Table 2 represent computed average values over the duration of each test (300 s) and they do not include the 10 s transitory periods at the beginning and at the end. Regardless of the nature of the background traffic, the QOAS system scored highly in terms of perceived quality, loss rate, and bottleneck link utilisation. QOAS streaming maintained loss rates of less than 0.1% in all cases, despite the fact that the delivery network was fully loaded. The perceived quality scores are not only above the "good" perceptual level (4.00 on the ITU-T scale), but also in almost all cases they are within 1% of the ideal adaptive scheme. The bottleneck link utilisation reached very high levels, with QOAS using more than 99.6% of the bandwidth resources in the majority of cases. These results indicate near-ideal performance of QOAS in all traffic conditions.

Conclusions and Further Work: This paper presents the performance of a QOAS-based system for VoD in local multi-service IP networks in highly congested traffic conditions and in the presence of various types, sizes and shapes of background traffic. The results are impressive even in comparison with an ideal adaptive scheme that could use all the available bandwidth for streaming without incurring losses. Further work includes carrying out subjective perceptual tests on a prototype system to verify the end-user quality results presented here.

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Table captions:

Table 1. Cross traffic for simulation tests: types, sizes and shapes

Table 2. Test results: QOAS vs. Ideal Adaptive Systems

Table 1

Traffic Code	Traffic Type	Traffic Shape	Size (Mb/s)	Other Traffic CBR Size (Mb/s)
A	CBR UDP	Periodic	1 x 0.7	96.0
B	CBR UDP	Staircase up	4 x 0.6	95.5
C	CBR UDP	Staircase down	4 x 0.6	95.5
D	VBR UDP	0.001s on 0.1s off	1 x 0.8	95.5
E	TCP	FTP	54 x 0.42	75.0
F	TCP	WWW	50 x 0.018	95.5

Table 2

Traffic Code	QOAS Tx. Rate (Mb/s)	Ideal Tx. Rate (Mb/s)	QOAS Quality (ITU T-R)	Ideal Quality (ITU T-R)	QOAS Loss Rate (%)	QOAS Utilis. (%)
A	3.33	3.55	4.46	4.50	0.0	99.72
B	3.03	3.09	4.31	4.39	0.09	99.95
C	3.02	3.30	4.31	4.45	0.006	99.63
D	3.74	3.82	4.53	4.55	0.0	99.85
E	2.73	2.78	4.29	4.31	0.04	98.43
F	3.50	3.59	4.49	4.51	0.0	99.80