



Rate Adaptive Video Multicast in Multirate Wireless Networks

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Abstract: *Adapting modulation and transmission bit-rates for video multicast in a multi rate wireless network is a challenging problem because of network dynamics, variable video bit-rates and varied clients who may expect differentiated video qualities. Prior work on the leader-based schemes selects the transmission bit-rate that provides reliable transmission for the node. In this paper, we investigate a rate-adaptive video multicast scheme that can provide varied clients differentiated visual qualities matching their channel conditions. We propose a rate scheduling model that selects the optimal transmission bitrates for each video frame to maximize the total visual quality for a multicast group subject to the minimum-visual-quality-guaranteed constraint. We then present a practical and easy-to-implement protocol, called Quality-Differentiated Multicast (QDM), which constructs a cluster-based structure to characterize node difference and adapts the transmission bit-rate to network dynamics based on video quality. Since QDM selects the rate by a sample-based technique, it is suitable for real-time working.*

Index Terms: *Wireless Video Multicast, Rate Adaptation, Wireless Network, QDM, PSNR.*

I. INTRODUCTION

Video streaming is arguably one of the most popular multimedia applications over wireless networks today. With the ubiquitous of such applications, constant demand for better wireless access technology has resulted in several generations of new access point (AP) products. Future-generation APs are expected to have much greater computation capability and storage capacity. They offer new opportunities to incorporate even more advanced features to support a variety of applications [1]. In this paper, we consider a new AP feature, namely quality-differentiated video multicast, to allow better utilization of limited wireless resources for video streaming. Taking advantage of the wireless broadcast nature, a video source can multicast a video object to a group of multicast members in order to reduce the bandwidth requirement [2], as compared with unicasting the data to each individual member. If certain members in the multicast group are capable of receiving packets at a higher bit rate [3] [4], and desire a better visual quality [5].

To address this problem, we propose a dynamic rate adaptation [6] scheme with quality-differentiated features to better support heterogeneity in the clients. Other work studies the rate adaptation schemes for multicast video streaming [7]. To avoid this effect, some multicast rate adaptation[8] schemes select the member who experiences the worst channel condition as the leader of the multicast group, and predict a bit rate that can reach this leader (the worst node). Such a leader-based approach is particularly suitable for applications that need to deliver data to all members reliably, e.g., data dissemination. However, this approach may not be efficient for video multicast [9] because it merely selects the rate that maximizes the throughput of the worst node. In doing so, it penalizes those nodes who can receive data at a higher bit rate. The rate selection problem in video multicast scenarios is more challenging due to heterogeneity of receivers. Since various members may observe different channel conditions, they can receive data sent at different bit-rates shown in the fig (1).

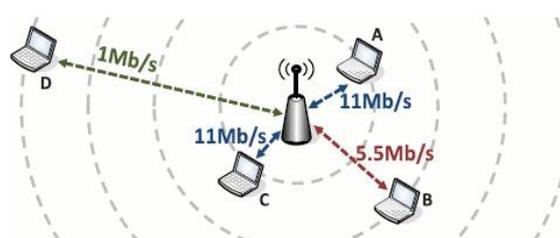


Fig 1: Heterogeneity of Multicast Members. Users A and B can receive Packets sent at 11 Mb/s in the MAC layer, while user D can only receive packets at the base-rate.

II. RELATED WORKS

Leader based scheme (LBP) selects one of the multicast group receivers as the leader. On erroneous reception of a data frame, the leader does not send an acknowledgement (ACK), prompting a retransmission. On erroneous reception of the data frame at the non-leader receivers, LBP allows negative acknowledgements (NACKs) from these receivers to collide with the ACK from the leader, thus destroying the ACK and prompting the sender to retransmit the data frame.

Transmission bit-rates for video multicast in a multi rate wireless network is challenging problem selects the transmission bit-rate that provides reliable transmission for the node most work on rate selection for wireless multicast focuses on achieving multicast reliability by selecting the rate that can deliver data reliably to the member with the worst channel condition. It selects the worst node as the leader to acknowledge multicast packets. Other members can issue negative acknowledgements to collide the acknowledgement sent by the leader and, thus, trigger the sender to retransmit the lost packets. The goal of LBP is to support reliability by a single feedback. However, it does not adapt the transmission bit rate to dynamic channel conditions, but only sends data at the base rates.

III. PROPOSED APPROACH

1) RATE - ADAPTIVE VIDEO MULTICAST SCHEME (OR) RATE SCHEDULING MODEL

Select the transmissions bit-rate and adapt the modulation for optimal video transmission heterogeneous clients differentiated visual qualities matching their channel conditions easy-to-implement protocol is called QDM.

2) QUALITY-DIFFERENTIATED VIDEO MULTICAST

We propose a practical protocol, called Quality-Differentiated Multicast (QDM), which exploits a sample-based technique to adapt the transmission bit-rate of each video frame to variable video bitrates and client mobility without the need of any preprocess. Thus, it can be applied to real-time video streaming it is a cluster-based structure it is suitable for real-time streaming even without any pre-process QDM transmission to variable bit-rate QDM using video-bit rates shown in fig (2).

Our simulation results show that not only can QDM provide users differentiated video quality matching their channel conditions, but also produce a better average visual quality as compared with the leader-based schemes.

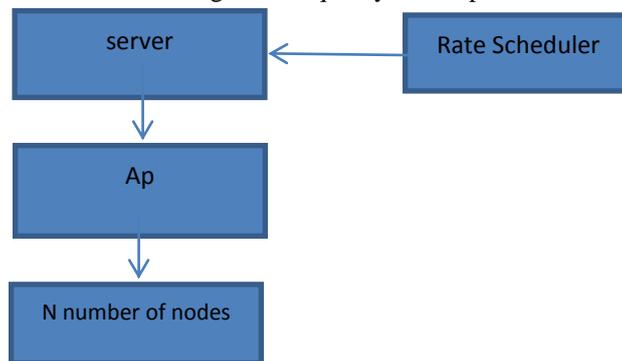


Fig 2.Qdm architecture

3) RATE ADAPTATION

Two – stage rate adaptation is used. It adapts the rate schedule to variable video bit rates and channel conditions shown in fig (3). and at the same time avoids the unnecessary sampling overhead.

a) Active state:

The system stay in the active state if the clients are mobile or the video bit-rate varies with time. In this state, we repeat the sampling procedure for each sampling interval, which is set to a fixed size (e.g., set to six GOPs in our simulations).Hence, the system can sample a better rate periodically.

b) Static state:

If the system selects the same rate for k (set to 2 in our simulations) continuous sampling intervals it then switches from the active state to the static state because the selected

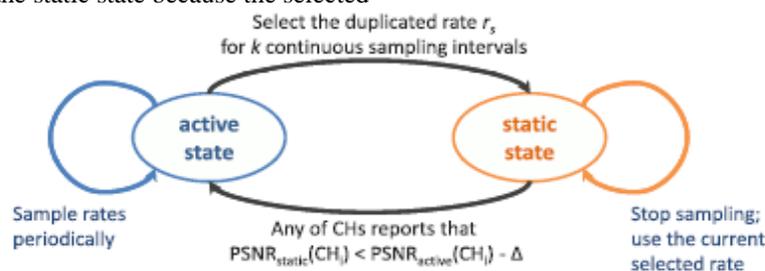


Fig 3: Two stage- rate adaptation

4) PEAK SIGNAL-TO-NOISE RATIO (PSNR)

The different transmission bit-rate for each video frame according to its importance so that members can receive differentiated video quality that best so that each member can achieve at least the minimum visual quality PSNR min. The goal is to provide heterogeneous clients differentiated visual qualities matching their channel conditions. Most work on rate selection for wireless multicast focuses on achieving multicast reliability by selecting the video bit-rate that can deliver data reliably to the member.

IV. EXPERIMENTAL RESULTS

We formulate the rate scheduling problem as a theoretical optimization model, and utilize a dynamic programming algorithm to compute the solution using oracle information. This model needs a high computational complexity and complete information about the packet loss probability of each wireless link.

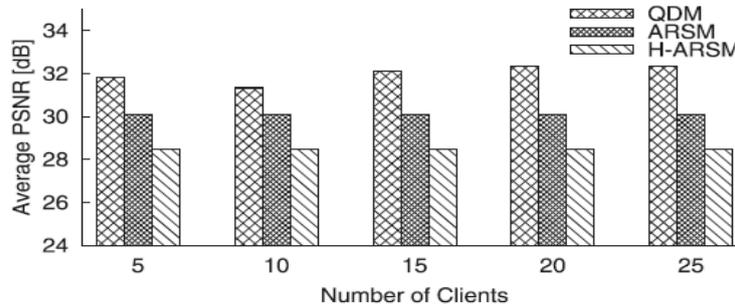
Algorithm 1. Dynamic programming solution to the rate scheduling problem

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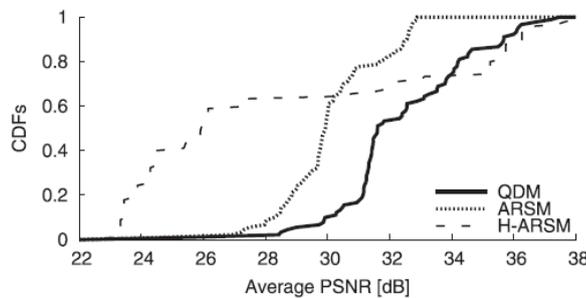
1: Initialize  $Q[k, t] = 0$  for  $0 \leq k \leq K, 0 \leq t \leq \lfloor T_{diff} \rfloor$ 
2: for  $t = 1$  to  $\lfloor T_{diff} \rfloor$  (Test each size of knapsack) do
3:   for  $k = 1$  to  $K$  (Go through each frame  $f_k^n$ ) do
4:     if Use MDC then
5:        $Q[k, t] = \max\{Q[k-1, t], \Delta Q(f_k^n, r_i) + Q[k-1, t - \lceil \frac{len(f_k^n)}{r_i} \rceil] : r_i \in R, t \geq \lceil \frac{len(f_k^n)}{r_i} \rceil\}$ 
6:     else if Use predictive coding then
7:        $r = \arg_{r_i} \max\{\Delta Q(f_k^n, r_i) + Q[k-1, t - \lceil \frac{len(f_k^n)}{r_i} \rceil] : r_i \in R, t \geq \lceil \frac{len(f_k^n)}{r_i} \rceil, Q[k-1, t - \lceil \frac{len(f_k^n)}{r_i} \rceil] \neq -1\}$ 
8:       if  $r \neq \phi$  then  $Q[k, t] = \Delta Q(f_k^n, r) + Q[k-1, t - \lceil \frac{len(f_k^n)}{r} \rceil]$ ; else  $Q[k, t] = -1$ ; endif
9:     end if
10:   end for
11: end for
12: if Use MDC then  $PSNR_{total} = Q[K, \lfloor T_{diff} \rfloor]$ ;
    else  $PSNR_{total} = \max_{0 \leq k \leq K} Q[k, \lfloor T_{diff} \rfloor]$ ; endif

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We use real traces to examine the performance of QDM. We implement a trace-based test environment to evaluate the performance of QDM in real wireless channels. For each trace-based evaluation, we randomly assign k multicast clients to k randomly selected locations shows the PSNR comparison between our QDM and the previous schemes, such as ARSM and H-ARSM. The fig (4) shows that our QDM enables heterogeneous visual quality and therefore improve the average PSNR.



(a) Average Visual Quality



(b) CDFs of Visual Quality (25 clients)

Fig 4: Trace-based evaluation

V. CONCLUSION

In this paper investigated the rate scheduling problem of video multicast for heterogeneous clients over wireless environments, it have proposed a rate scheduling model that solves the theoretical optimal solution by dynamic programming. A further presented for real-time video streaming even without preprocess on computing the rate-distortion function and estimating the loss probability of each wireless link. In QDM, we exploit a cluster-based structure to provide differentiated qualities for heterogeneous clients. Based on the information reported by cluster heads, the sender can estimate the total video quality and explore a suitable rate for each video frame based on a sample-based, while also guarantee that each client perceives at least a minimum video quality. In addition, the two-state rate-adaptation scheme in QDM can adapt the rate to network dynamics and variable video bit rates with a reduced sampling overhead.

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