

P2P Video Multicast for Wireless Mobile Clients

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Abstract— Mobile TV is a new interesting area in the telecommunication industry. The technology for sending live video to mobile clients is characterized by relatively low CPU processing power, low network resources and low display resolution. In this paper we discuss a solution to all of these problems by using application layer multicasting. This can significantly reduce the needed bitrate and required computing resources for each client. At the same time the received video quality is increased. Several different methods for splitting the video into substreams are discussed. A system for application layer multicasting using layered H.264 is also presented.

I. INTRODUCTION

High-bandwidth live media distribution is very important in many applications, ranging from mobile entertainment to mobile services of industries where for example a technician needs to access 3D visualization of dynamic processes. The technical challenge lies in the fact that mobile clients have very limited network resources, about 30 kb/s for GPRS and 100 kb/s for 3G networks, which greatly limits their ability to access the high-quality media information. The solution is to let the team make use of short-distant wireless communication to build a cooperative environment and multicast the live content within the team. Unfortunately, traditional IP multicast system doesn't work. An alternative is to use the application-level multicast. The idea is that the mobile hosts pool their resource to route and distribute multicast messages using only unicast network service.

The local wireless communication can be built up using for example Bluetooth or IEEE 802.11. To extend the coverage a multihopping ad-hoc network can be used. Here all nodes also act as routers and can relay information for each other. In this network the nodes are free to move randomly and organize themselves arbitrarily. This is a fully autonomous system that works without preexisting infrastructure. Ad-hoc networks has been an active research area for a while and several protocols has been proposed. Two examples of the most commonly used ad-hoc routing protocols are AODV [1] and DSR [2].

A Peer to peer application layer multicast approach for sharing files on Internet has been used for some time. One of the most commonly used protocol for this is BitTorrent [3]. Peer to peer media multicasting has also been considered in several papers [4] [5] [6]. None of these do however consider the case for video distribution for mobile handheld devices. These devices are characterized by relatively low CPU processing power, low display resolution and low bitrate.

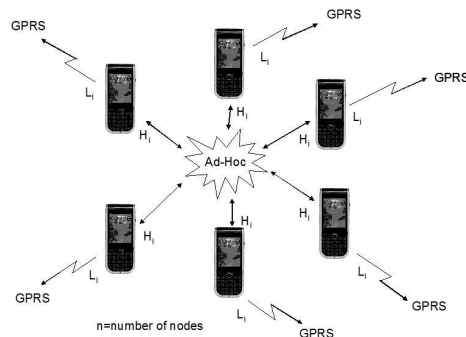


Fig. 1. Overview of the system

The video must be split into several substreams to make it possible to use application level multicasting. This can be done in several different ways. The two most commonly used methods are multiple description coding and layered coding [7]. The multiple description coding is very flexible. The quality of the received video improves with each received description. The total bitrate needed for the multiple description system to achieve a given distortion will however be relatively much higher than the bitrate needed to achieve the same distortion using a single stream. Layered coding can achieve both spatio-temporal and quality scalability. The coding efficiency for this technique is also relatively high. The drawback of layered coding is that the decoding process requires rather much computing resources compared to single layer coding. This is a major problem for the mobile clients that are usually battery powered and have very limited computing resources. Another method for creating substreams of the video is to divide the video into areas where the areas are coded to independent streams. The first user in a group will receive the most important area. If there are two users the two most important areas should be transmitted, and so on. This will require very low computing resources since each user only decodes a part of the entire video.

II. SCALABLE H.264 FOR P2P MULTICAST

Assume that a group of users are watching the same real-time video over a GPRS connection. We also assume that these users are equipped with a local wireless connection, for example Bluetooth or 802.11. See figure 1 for an overview of

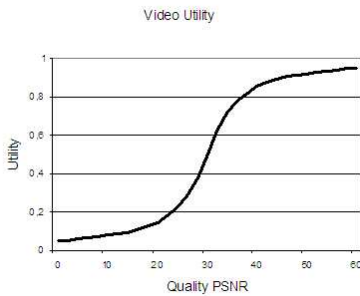


Fig. 2. The utility as a function of the PSNR

	bitrate	PSNR
Layer 0	15,0	31,1
Layer 1	24,6	32,6
Layer 2	50,5	35,3
Layer 3	82,8	37,1
Layer 4	132,7	39,0
Layer 5	207,7	40,9

TABLE I
QUALITY AND BITRATE FOR THE DIFFERENT LAYERS

the system. The bitrate on the GPRS connection is relatively low, 30 kbit/s. The cost for sending data on the GPRS connection is in this example set to 20 SEK/MB. For the local wireless connection the bitrate is much higher compared to the GPRS connection. We can expect to have a bitrate from a few Mbit/s to more than 50 Mbit/s on this connection. In this example we set the maximum bitrate for the local network to the sum of all users GPRS bitrate. There are no costs for sending on the local wireless connection.

Video quality is usually measured as peak signal to noise ratio (PSNR). This measurement does however not correspond very well to the subjective video quality. We therefore use a utility function that describes the subjective video quality as a function of the PSNR. A video having a PSNR below 30 dB is considered bad and a PSNR above 40 dB is considered as good quality. From this numbers we estimate a utility function, see figure 2. The video quality measured as PSNR for each user, Q_i , is a function of the systems total GPRS bitrate.

We use the scalable extension of H.264/AVC from Fraunhofer HHI [8]. This codec makes it possible to create several substreams of the video. In this example we are using six layers, these are described in table I. This makes it possible to receive video having bitrates from 15.0 kbit/s to 207.7 kbit/s in six different steps.

We assume that all users share the cost. The bitrate on the GPRS connection for each user, R_i , is therefore the total video bitrate divided by the number of users.

The goal of the system is to maximize the sum of all users total utility (1). First we have the utility from the video quality, U_i . We also have a negative utility for the cost on the GPRS

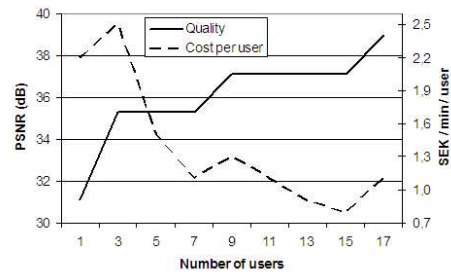


Fig. 3. The quality and cost per user as a function of the number of users

connection. This is a function of the bitrate on the GPRS connection, R_i , and the cost, C_i . In this example we simply use a factor, λ , to create a linear utility function for the cost.

$$\max \sum_{i=0}^n (U_i - \lambda C_i R_i) \quad (1)$$

In figure 3 we can see that when the number of users is increased the video quality will be higher. At the same time the cost per user will also decrease. In this example the PSNR is 31.1 dB when only one user is connected. This user has to download 15 kbit/s on the GPRS connection and the cost per user and minute will be 2.2 SEK/min in this case. When 17 users are connected the PSNR is 39 dB. Now each user only have to download 7.8 kbit/s and the cost per user will be 1.1 SEK/min. We can see that application level multicasting can successfully be used to overcome the technical challenges of streaming live media to mobile clients.

III. ACKNOWLEDGMENT

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REFERENCES

- [1] C. Perkins, E. Belding-Royer, and S. Das. Ad hoc on-demand distance vector (aodv) routing. RFC 3561, July 2003.
- [2] David B. Johnson, David A. Maltz, and Yih-Chun Hu. The dynamic source routing protocol for mobile ad hoc networks (dsr). Draft 9.
- [3] Bram Cohen. Incentives Build Robustness in BitTorrent. In *Proceedings of Workshop on Economics of Peer-to-Peer Systems*, Berkeley, CA, USA, June 2003.
- [4] Mohamed Hefeeda, Ahsan Habib, Boyan Botev, Dongyan Xu, and Bharat Bhargava. Promise: peer-to-peer media streaming using collectcast. In *MULTIMEDIA '03: Proceedings of the eleventh ACM international conference on Multimedia*, pages 45–54, New York, NY, USA, 2003. ACM Press.
- [5] Miguel Castro, Peter Druschel, Anne-Marie Kermarrec, Animesh Nandi, Antony Rowstron, and Atul Singh. Splitstream: High-bandwidth content distribution in a cooperative environment. In *Proceedings of the 2nd International Workshop on Peer-to-Peer Systems (IPTPS03)*, Berkeley, CA, USA, February 2003.
- [6] Duc A. Tran, Kien A. Hua, and Tai Do. Zigzag: an efficient peer-to-peer scheme for media streaming. In *Proceedings of IEEE INFOCOM 2003*, San Francisco, CA, USA, March 30-April 3 2003.
- [7] Y. Shen, Z. Liu, S. Panwar, K.W. Ross, and Y. Wang. Peer-driven video streaming: Multiple descriptions versus layering. submitted.
- [8] Ralf Schäfer, Heiko Schwarz, Detlev Marpe, Thomas Schierl, and Thomas Wiegand. Mctf and scalability extension of h.264/avc and its application to video transmission, storage, and surveillance. In *Proceedings of VCIP 2005*, Peking, China, July 2005.