An Efficient Multiple Description Coding for Video Streaming

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Abstract
The number of users is rapidly expanding and bandwidth-hungry services, such as video streaming, are becoming more and more popular by the day. Multiple description coding (MDC) can be used to address this bandwidth heterogeneity issue. The goal of MDC is to create several independent descriptions that can contribute to one or more characteristics of video: spatial or temporal resolution, signal-to-noise ratio, frequency content. An important but challenging problem for MDC video multicast is how to assign bandwidth to each description in order to maximize overall user satisfaction. In this paper, we propose to implement an efficient heuristic called simulated annealing for MDC bandwidth assignment to assign bandwidth to each description given the distribution of user bandwidth requirement. Main objective is to maximize user bandwidth experience by taking into account the encoding inefficiency due to MDC. If the description number is larger than or equal to a certain threshold, then by implementing proposed technique we can achieve maximum user satisfaction, i.e., meeting all the bandwidth requirements.

Keywords
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I. Introduction

With the emergence of broadband wireless networks and increasing demand for multimedia information on the Internet, wireless video communications have received great interests from both industry and academia, and wireless multimedia services are foreseen to become widely deployed in this decade. Real-time transport of live video or stored video is the predominant part of real-time multimedia. Video streaming is the main approach for delivery of stored video over wire line networks such as the Internet, where the streaming video is partitioned into packets and played out simultaneously during video delivery. In comparison with video download, video streaming has the advantages of a low (initial) delay and requiring a small storage space.

In general, users want maximum speed and minimum delay even using a minimum bandwidth required network applications. On the other hand, in real-time applications such as video streaming, TV broadcasting or video-conferencing, the service quality must be maximized for satisfying the users. Some users never know what exactly happens after starting a real-time application. They only take the quality into consideration, other facts are not important for them. The more you pay for the bandwidth, the more you expect. Unfortunately, today's technologies cannot provide the best solutions for video streaming users that use best effort delivery networks.

To stream video to a large group of users, meeting heterogeneous bandwidth requirements presents a challenging problem. A simple approach is to encode the video into a number of streams of different bitrates, which users join to best match their bandwidth requirements. Given the wide range of bandwidth requirements and limited number of video streams, this approach is clearly not satisfactory. A much better approach is to use multiple description coding (MDC), which encodes the video into multiple independent "descriptions" of different bandwidth. The descriptions can be arbitrarily combined to best match user's bandwidth requirement. Such approach provides many more options of video bitrates to meet different user requirements.

In this paper, we propose an efficient MDC bandwidth assignment technique which handles two types of problems. They are: (1) If the description bandwidths are set too low, those high-bandwidth receivers may not be able to fulfill their bandwidth by joining them, leading to low video quality.(2) if description bandwidths are set too high, the low bandwidth receivers may not benefit from them (as joining them may exceed their bandwidth), leading again to low video quality. The proposed technique i.e., simulated annealing for MDC bandwidth assignment will assign bandwidth to each description given the distribution of user bandwidth requirement which maximize user bandwidth experience by taking into account the encoding inefficiency.

II. Realted Work

Streaming is very popular in today's best effort delivery networks. Delivering audio or video content over the Internet can be achieved by two methods: progressive download and real-time streaming. If the content size is short, the progressive download method is used in general. In this method, media content is directly downloaded from a server into storage units of a client, but in real-time streaming, client software plays media content without storing the content into any storage units. Real-time streaming can be easily explained as delivering media from a server to a client over a network in real-time. The client software is responsible for playing the media as it is delivered. There are two main types of delivery options for real-time streaming: live and on demand. Simulated live is also another method that is used with live streaming or on-demand as a part of them to add some extra materials such as prerecorded scenes, concerts, interviews and lectures, but this event is not live and there is no need any broadcasting tools. If the media content contains live events, this type of streaming is called live streaming. On the other hand, if the media contents can be provided on user's demand, it is called on-demand streaming. Multiple description coding (MDC) has found numerous applications in video streaming.

Simulated annealing was first proposed by Kirkpatrick et al. in 1983 as a framework to find approximate solution for difficult combinatorial optimization problems. It takes the concept from statistical mechanics and is inspired by the behavior of the physical system in the annealing process. Given a combinatorial problem, a local optimization technique iteratively improves an initial solution by making small local alternations. The cost is lowered down after each iteration and a local optimum is found if the cost cannot be lowered any further. Simulated annealing is one of the local optimization techniques; however, it advances in its ability to approach global optimum by randomizing the process. The randomization is done by occasionally allowing a solution with higher cost in order to avoid being trapped in the local optima. The degree of randomization (i.e., intuitively, the probability of accepting a higher cost solution) is gradually lowered down to ensure the algorithm converges a local optimum. This process is

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analogous to the process of slowly cooling down in annealing. It is proved that simulated annealing can find the global optimum by carefully decreasing the degree of randomization.

III. Multiple Description Coding

It is not easy to design and implement a Multiple Description video coding scheme. There are many established video coding standards deployed in the real world: e.g. MPEG-2, MPEG-4, H.263 and H.264. It is difficult to impose yet another standard which is more complex. There are many other techniques available for creating multiple descriptions: multiple description scalar or vector quantization, correlating transforms and filters, frames or redundant bases, forward error correction coupled with layered coding, spatial or temporal polyphase downsampling (PDMD).

Multiple Description Coding is very robust, even at high loss rates. It is unlikely that the same portion of a given picture is corrupted in all the descriptions. A more sophisticated point of view is to note that descriptions are interleaved. In fact, when the original picture is reconstructed, descriptions are merged by interleaving pixels. A missing portion in one description, will results in scattered missing pixels. These pixels can easily be estimated by using neighbouring available pixels. It is assumed that errors are independent among descriptions. This is true only if descriptions are transmitted using multiple and independent channels. If one single channel is used instead, descriptions have to be suitably multiplexed. If this is done, error bursts will be broken by the demultiplexer and will look random, especially if the burst length is shorter than the multiplexer period.

when Multiple Description is used, a terminal can decode only the number of descriptions that suits its power, memory or display capabilities. Also, when the channel has varying bandwidth, it would be easy to adapt the transmission to the available bandwidth. Descriptions may simply be dropped. Instead, a non-scalable bitstream would require an expensive transcoding. When MD coding is used, there is no "base" layer. Each description can be decoded and used to get a basic quality sequence. More decoded descriptions lead to higher quality. There is no need to prioritise or protect a bitstream.

IV. Algorithms for Bandwidth Assignment

Here, we present the threshold value for description number. We show that when the description number is no less than the threshold, there is a simple and efficient assignment algorithm to match all the user bandwidth requirements.

If description is less than the threshold, the problem is to search in an integer space for the optimal description bandwidths. The search space is discrete and finite, because each description can only take integral bandwidth no larger than the maximum bandwidth requirement in the network. This condition makes it feasible to adopt simulated annealing algorithm to solve the problem. The simulated annealing algorithm starts with an initial state and iteratively transits to other state seeking for lower internal energy.

Each state has a neighborhood given by a specified radius and at each iteration, randomly picks a neighbor of the current state as the target state, and decides whether or not to make the transition according to a transition probability. Later we define a temperature, which exponentially decreases as the algorithm iterates. At the early iterations when the temperature is high, simulated annealing algorithm picks the target state from a large neighborhood. Because the transition probability to any picked state is high, the algorithm randomly moves among the states. As the algorithm iterates, the temperature gets lower. Simulated annealing algorithm picks the target state from a smaller neighborhood and the transition probability to a state of lower satisfaction decreases. In other words, the algorithm gradually settles to a neighborhood with locally-optimal satisfaction. By running algorithm with different initial states, we have great chance to find the global optimum.

V. Performance

The Multiple Description Coding is applicable for:

A. Divide-and-Rule Approach to HDTV Distribution

HDTV sequences can be split into SDTV descriptions; no custom high-bandwidth is required.

B. Easy Picture-in-Picture

with the classical solution, a second full decoding is needed plus downsizing; with MDC/LC, it is sufficient to decode one description or the base layer and paste it on the display.

C. Adaptation to Low Resolution/ Memory/ Power

Mobiles decode as many descriptions/layers as they can – based on their display size, available memory, processor speed and battery level.

D. Pay-Per-Quality Services

The user can decide at which quality level to enjoy a service, from lowcost low-resolution (base layer or one description only) to higher cost high-resolution (by paying for enhancement layers / more descriptions).

E. Easy Cell Hand-Over in Wireless Networks

different descriptions can be streamed from different base stations exploiting multi-paths on a cell boundary.

F. Adaptation to Varying Bandwidth

The base station can simply drop descriptions/layers; more users can easily be served, and no trans-coding process is needed.

G. Enhanced Carousel

Instead of repeating the same data over and over again, different descriptions are transmitted one after another; the decoder can store and combine them to get a higher quality.

The comparison shows proposed technique performs as well as exhaustive search and is robust when the bandwidth requirement distribution changes. Besides, exponential assignment performs better than uniform assignment and much better than linear assignment and random assignment. Linear assignment and random assignment have the similar performance.

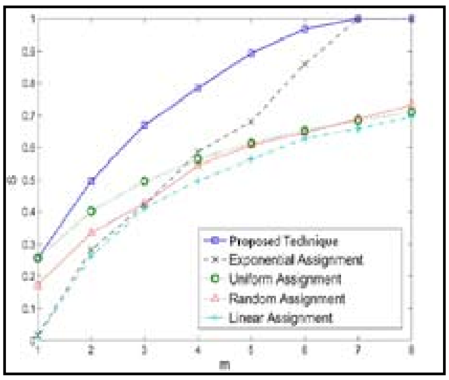

Fig. 1. Overall Satisfaction(s) Versus Description Number(m) Given Different Schemes

The above fig. shows the overall satisfaction versus number of descriptions given different bandwidth assignment schemes. The overall satisfaction increases S with M. This is because more descriptions can provide more options of bitrates to meet heterogeneous user bandwidth requirements. For each M, proposed technique performs as well as exhaustive search and much better than the other schemes. The satisfaction of proposed technique finally settles to a value, because all the bandwidth requirements are fully matched M after reaches the threshold. Exponential assignment achieves the same performance after reaches M the threshold.

VI. Conclusion

To stream video to a large group of users, meeting heterogeneous bandwidth requirements presents a challenging problem. In this paper, we propose an efficient MDC bandwidth assignment technique which handles two types of problems. They are:

1. If the description bandwidths are set too low, those high-bandwidth receivers may not be able to fulfill their bandwidth by joining them, leading to low video quality.
2. if description bandwidths are set too high, the low bandwidth receivers may not benefit from them (as joining them may exceed their bandwidth), leading again to low video quality. The proposed technique i.e., simulated annealing for MDC bandwidth assignment will assign bandwidth to each description given the distribution of user bandwidth requirement which maximize user bandwidth experience by taking into account the encoding inefficiency.

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