Packet-Level Traffic Allocation for Real-Time Streaming over Multipath Networks

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Abstract. We address packet-level traffic allocation problem for real-time media streaming under multipath network environment. Based on an in-depth analysis of multipath real-time streaming model, also considering fluctuation of multipath network status as well as burst of media sending rate, we suggest that traffic load should be allocated to paths in proportion to the paths’ available bandwidths, which minimizes the overall bandwidth overload probability. Moreover, due to the smallest transmission unit is packet, in order to execute the traffic allocation policy exactly, weighted size-aware packet distribution algorithm is proposed to avoid the actual traffic deviation due to variance of packet sizes. Simulation results show that the proposed algorithm outperforms other traditional algorithms, especially for reducing packet late arrivals, which has negative impaction in real-time transmission.

Keywords: traffic allocation, multipath, real-time streaming, available bandwidth, path redundance.

1 Introduction

In despite of the development of novel network infrastructures and constantly increasing bandwidth, Internet media streaming applications still suffer from limited and fluctuated bandwidth. Multipath streaming transmission has recently been proposed as a solution to overcome packet networks limitations [1], [2], [3]. It allows to increase the streaming bandwidth by balancing the load over multiple disjoint network paths between media sender and receiver. It also improves the error resilience of the media streaming system by means of redundant paths. Essential to such a multipath streaming system, at sender, is the packet distributor that dispatches media packets to the paths. It is necessary for the sender to distribute workload in a reasonable manner so that the multipath system can achieve its full potential.

How to distribute packets to achieve maximum benefit? Numerous studies [3], [4], [5], have made contributions on this research field. The fundamental concept is to allocate traffic in terms of available bandwidth. While all these works do not consider the fluctuation of network status enough. Unlike these approaches, which rely on UDP for streaming, some researchers focus on exploiting TCP for multipath real-time streaming, imposing TCP’s state-awareness ability [6],
For real-time specific, based on UDP, we try to implement a dynamic traffic allocation mechanism to “sense” the transmission characteristics of each path, and distribute packets fairly over the paths to achieve the designed goal.

In the framework of multipath network as shown in Fig. 1, our work addressed to the problem of streaming packet distribution, which takes into account real-time streaming characteristics. We are aiming at distributing packets fairly in order to achieve efficient utilization of bandwidth resources. Two key challenges are what is the distribution policy and how to execute this policy exactly. By means of analyzing media specific scenario, this paper gives corresponding solutions of these challenges.

In this paper, we make the following three contributions. (i) We analyze end-to-end multipath real-time streaming system in depth, and provide a model of bandwidth overload probability. (ii) Based on the model, we prove that allocating traffic in proportion to paths’ available bandwidths respectively helps to reduce the overall overload probability. (iii) Following the traffic allocation policy, a weighted size-aware packet distribution algorithm for multipath real-time streaming is proposed, which is fine grained for its perceiving the smallest data unit (i.e. packet) over packet switching networks.

The rest of the paper is organized as follows. The multipath real-time streaming model is analyzed in Section II. Section III provides our optimal media-driven traffic allocation scheme and proves it. In section IV, we propose weighted size-aware packet distribution algorithm imposing upon traffic allocation policy. Simulation results are presented in Section V. Section VI concludes the paper.

2 Multipath Real-Time Streaming Analysis

2.1 Multipath Real-Time Streaming

We consider an end-to-end transmission framework where the media streaming application uses $M (M \geq 2)$ disjoint paths. Paths are considered to be disjoint if they do not share performance bottlenecks. The set of available loop-free paths between a media sender and a receiver is defined as $P = \{P_1, P_2, \ldots, P_M\}$.

For end-to-end perspective, we do look into the network status from an end-to-end point of view, rather than focus the hop-by-hop process during transmission. The network available bandwidth $b_i(t)$ (i.e., spare bandwidth), that is the bandwidth left unused by idle and non-greedy connections, is hence given by the following expression: