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Hybrid congestion control for high-speed networks

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ABSTRACT

Nowadays, more and more applications require fast transfer of massive data over networks, and the emergence of high-speed networks provides an ideal solution to this challenge. Due to the limitations of the conservative congestion control algorithm, the standard TCP is no longer appropriate for high-speed networks to efficiently utilize the bandwidth resources. Therefore, several high-speed TCP variants have been suggested to conquer the problem. However, although these protocols perform successfully to improve the bandwidth utilization, they still have the weakness on the performance such as RTT-fairness, TCP-friendliness, etc. In this paper, we propose HCC TCP, a hybrid congestion control algorithm using the synergy of delay-based and loss-based approach for the adaptation to high speed and long distance network environment. The algorithm uses queuing delay as the primary congestion indicator, and adjusts the window to stabilize around the size which can achieve the full utilization of available bandwidth. On the other hand, it uses packet loss as the second congestion indicator, and a loss-based congestion control strategy is utilized to maintain high bandwidth utilization in the cases that the delay-based strategy performs inefficiently in the networks. The two approaches in the algorithm are dynamically transferred into each other according to the network status. We finally perform simulations to verify the properties of the proposed HCC TCP. The simulation results demonstrate HCC TCP satisfies the requirements for an ideal TCP variant in high-speed networks, and achieves efficient performance on throughput, fairness, TCP-friendliness, robustness, etc.

1. Introduction

The rapid evolution of high-speed networks is significantly supporting the international collaborations with massive data transfer and computing resource sharing, and the networks, e.g. StarLight (2010), UKLight (2010), NetherLight (2010), CERN (2010), etc. integrated with 1–10 Gbps bandwidths have been developed and deployed over numbers of research institutions. In order to efficiently utilize the large bandwidths at the physical layer, researchers have focused on the developments of protocols at transport and network layers.

The standard TCP has been remarkably successful in performing congestion avoidance and control to prevent severe congestion in the current low-speed networks. However, it is well-known that the standard TCP is not appropriate for high-speed networks in terms of the additive increment multiplicative decrement (AIMD) algorithm is too conservative to rapidly achieve full bandwidth utilization while is too drastic to recover from per packet loss event. In order to conquer the poor performance problem, the standard TCP together with the AIMD algorithm should be modified in high-speed networks. So far, a number of high-speed TCP variants have been proposed, including the end-to-end approaches, e.g. HighSpeed TCP (HSTCP) (Floyd, 2003), Scalable TCP (STCP) (Kelly, 2003), HTCP (Leith and Shorten, 2004), BIC TCP (Xu et al., 2004), CUBIC TCP (Ha et al., 2008), FAST TCP (Wei et al., 2006), Compound TCP (CTCP) (Tan et al., 2006), TCP-Illinois (Liu et al., 2008) and the router-based approaches, e.g. XCP (Katabi et al., 2002), VCP (Xia et al., 2005). In addition, some researches focus on the application-level schemes on top of UDP to realize the congestion control functions for high-speed networks, such as UDT (Gu and Grossman, 2007). Although these approaches achieve higher throughput over the standard TCP in high-speed networks, most of them also have shortcomings in various aspects such as fairness, TCP-friendly, responsiveness, robustness, etc. Since none of the existing approaches is overwhelmingly better than the other protocols and has the convincing evidence that could be generally deployed, the development of new high-speed TCP variants is still needed.

In this paper, we introduce a new congestion control protocol, named hybrid congestion control TCP (HCC TCP), for high-speed networks. The protocol utilizes the delay information as the primary congestion indicator and utilizes the loss information as the second congestion indicator to jointly adjust the window

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