A Bandwidth Control Method with Fairness of High-speed Protocol Flows in Long-distance Broadband Networks

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Background and Purpose

In long-distance broadband networks, TCP (Transmission Control Protocol) cannot transfer a huge amount of data at high speed. Therefore, many researchers have recently developed high-speed transport protocols that have replaced TCP. These protocols transfer data at high speed by increasing the rate of data-transfer speed when there is no congestion and decreasing the ratio of data-transfer speed when there is congestion. High-speed transport protocols can also achieve the high throughput when there is only one kind of high-speed protocol flows. However, as shown in Figure 1, the sum of throughputs for each flow sometimes decreases, and when multiple flows using different high-speed transfer protocols coexist, a particular flow dominates the bandwidth and the other flows decrease the bandwidth. To solve these problems, we propose a new method of controlling networks; the method helps maintain a high link utilization and decreases the difference between bandwidths of coexisting flows in a link.

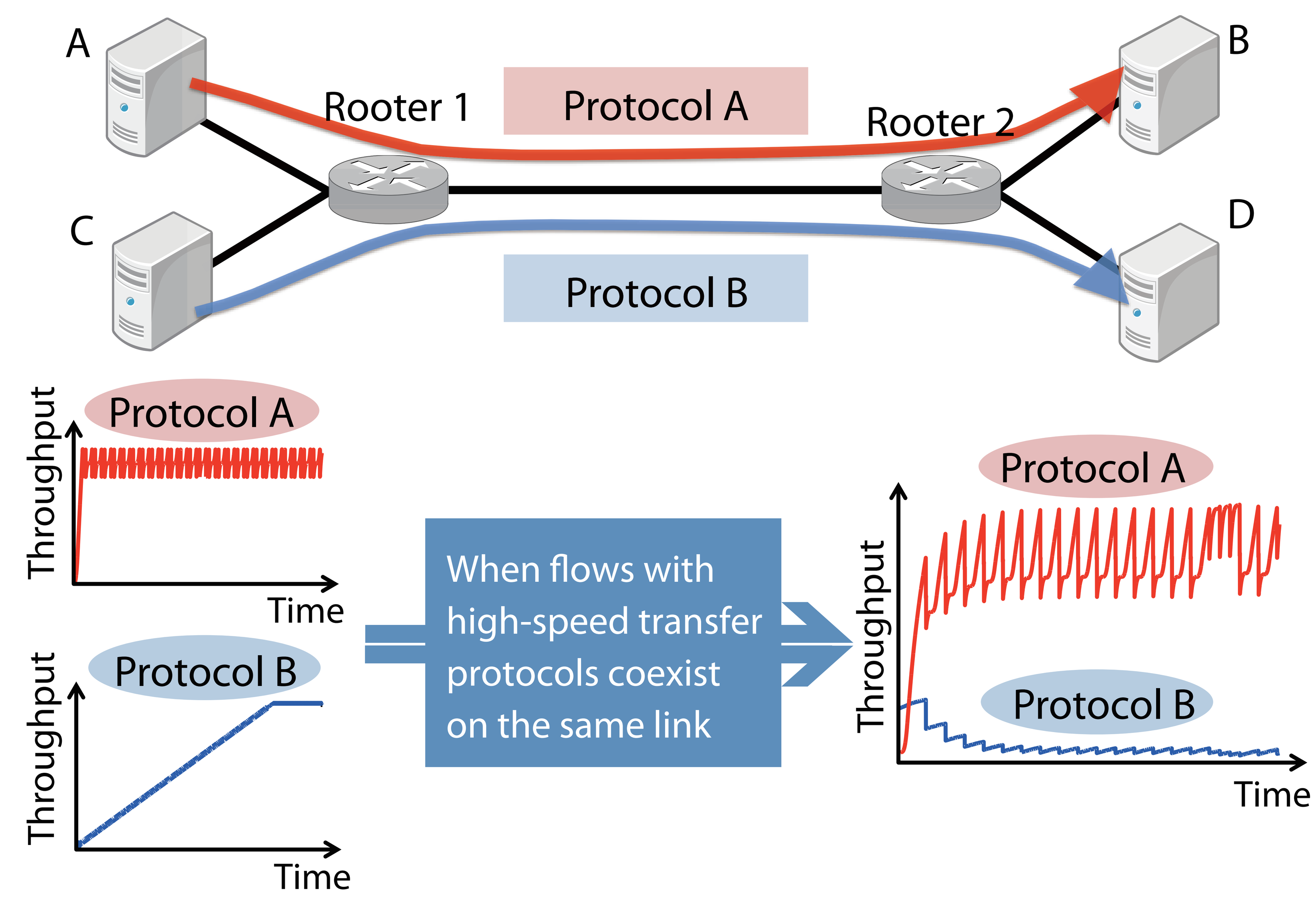

Figure 1: Protocol competition problem

Proposed Method

We focus on the dependence of the transfer rate on the RTT and the window size. We propose a new method for traffic control in the router. The method is devised by considering the characteristics of high-speed transport protocols, and it aims to decrease the difference between bandwidths of different flows. The method involves two types of control.

1. Estimation of the window size

Since the traffic in a long-distance broadband network is bursty, bursty packets arrive at the router every RTT. We propose a new control method that measures the packet arrival interval and estimates the window size and RTT. We consider the point of the end of the maximum packet interval as a cutting and dividing point of the RTT, as shown in Figure 2.

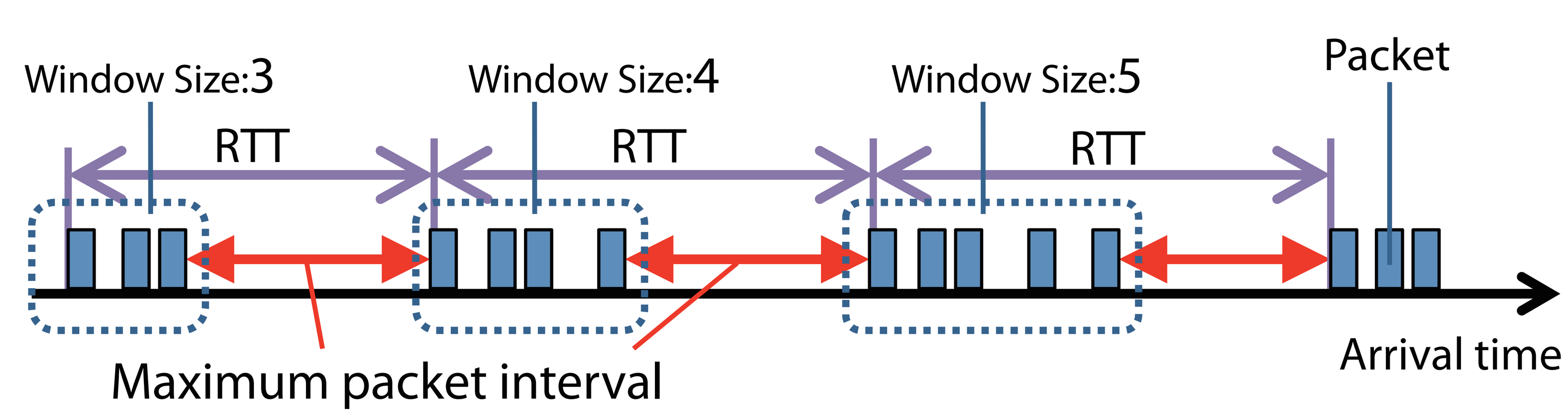

Figure 2: Estimation of the window size and RTT

2. Determination of dropping packets

First, the proposed method calculates the bandwidth to be allocated to each flow from the output bandwidth and the number of flows. Second, it determines the throughput from the estimated window size and RTT. Third, it calculates the moving average of the estimated throughput for each flow. Finally, since we drop packets when the moving average exceeds the allocated bandwidth, the average throughputs of the different flows are almost equal. The throughput may change as shown in Figure 3.

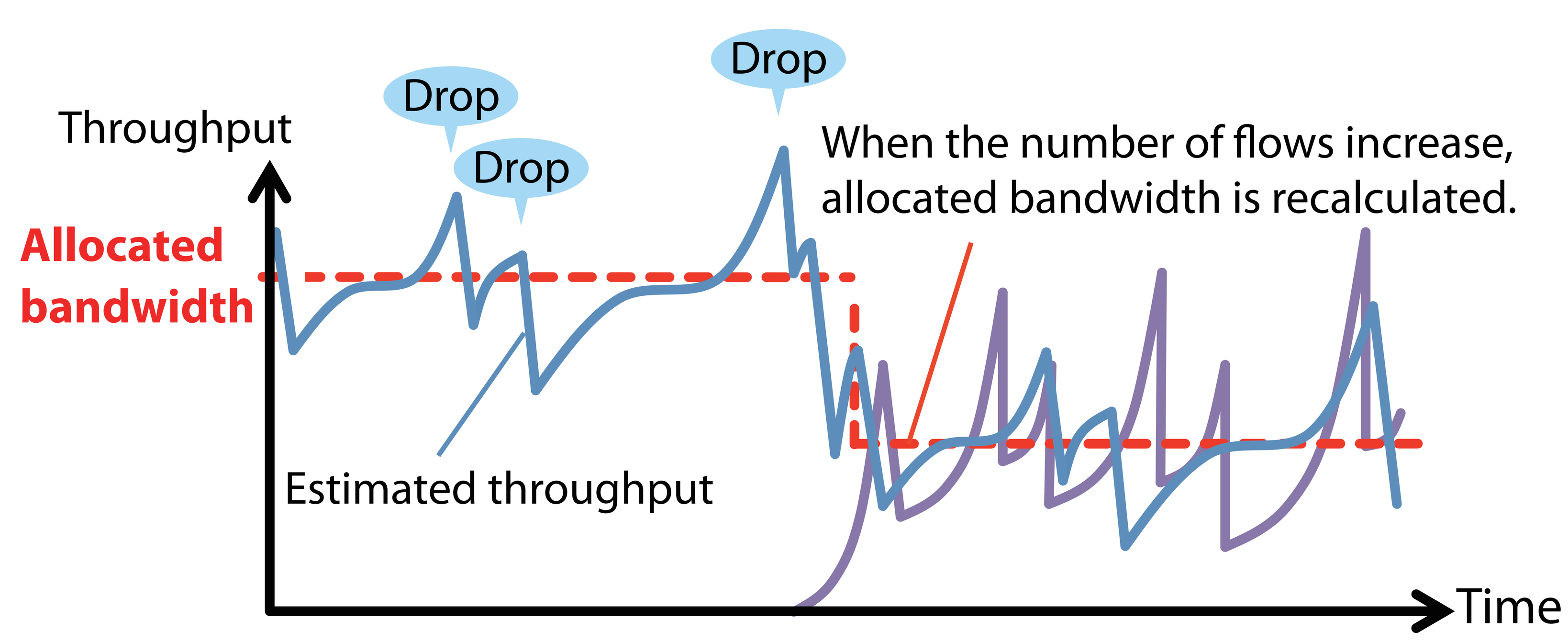

Figure 3: The image of time variation in estimated throughput

Performance Evaluation

We evaluate the performance of the proposed method by performing simulations with the network simulator ns-2. Figure 4 shows the network model used for the simulation. We use DropTail, RED, CSFQ, and the proposed method at the router. We also use HighSpeed TCP (HSTCP), CUBIC TCP, TCP Westwood, and Compound TCP (CTCP) as high-speed transport protocols. Figure 5 shows one of the simulation results obtained by using the average throughput and fairness index (FI) as performance measures. When the value of the FI is approximately 1, the link utilization is close to 100% and the difference between the bandwidths of flows is small.

Figure 5 shows that the total of the average throughputs of the flows obtained by using the proposed method is a little worse compared to those determined with other methods. On the other hand, we can achieve a high fairness index with the proposed method. Thus, the proposed method has high efficiency.

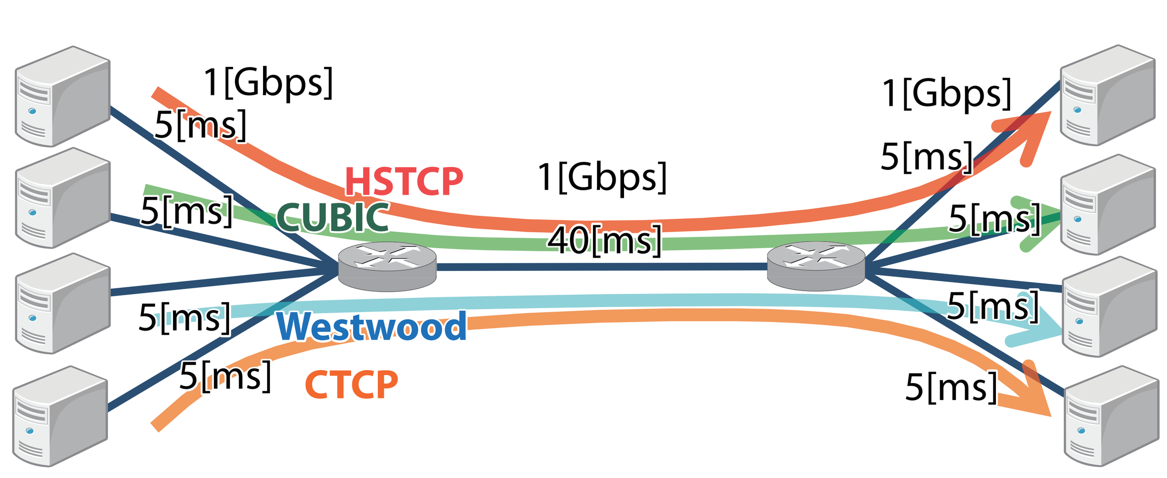

Figure 4: Simulation environment

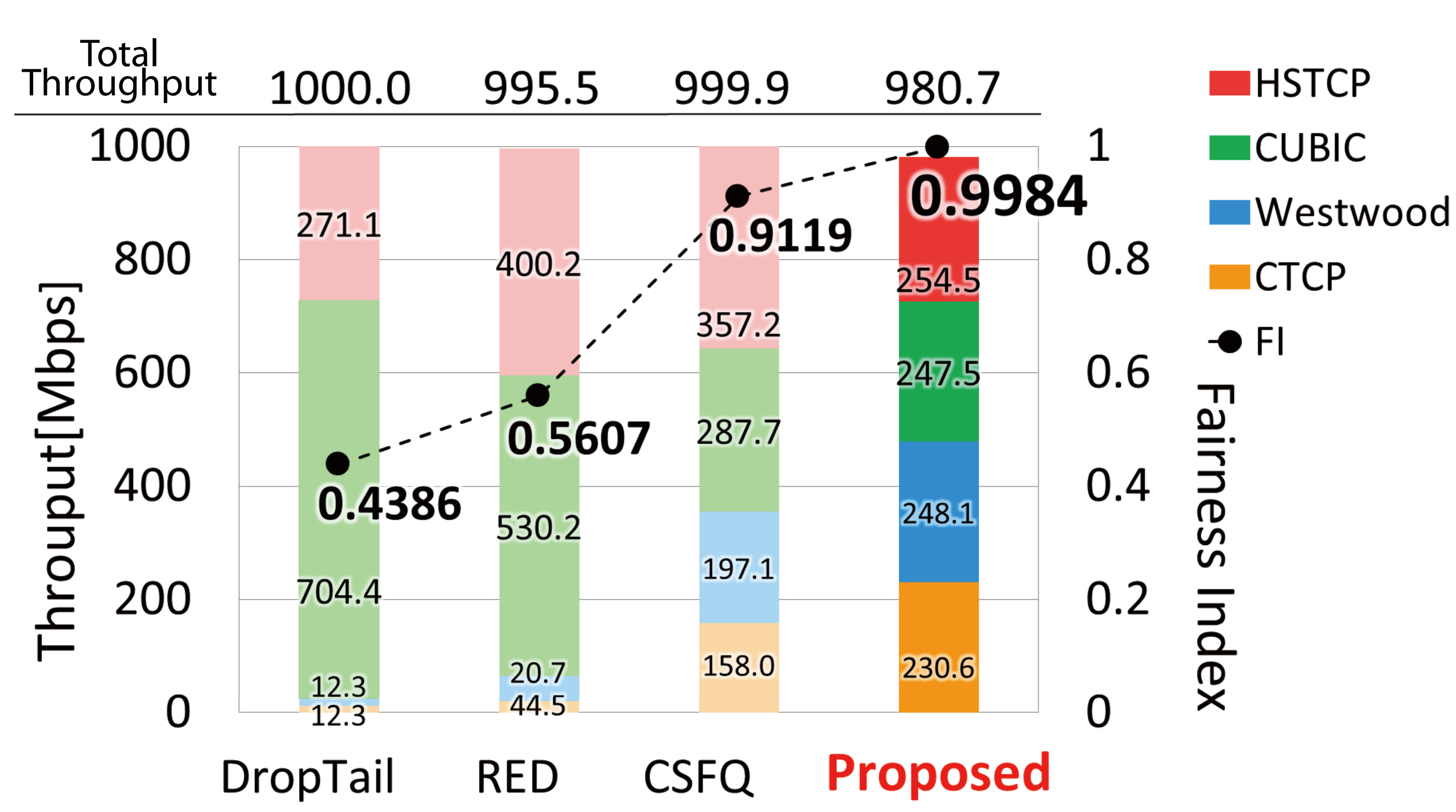

Figure 5: Average throughput and FI with four methods

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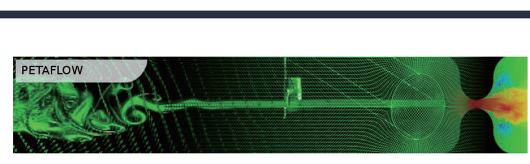

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