Chapter 1
Fairness Analysis and Improvement of Transport Layer Protocols

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ABSTRACT

The article presents a comparison of fairness properties of different congestion control schemes. It is hard to investigate the various protocol mechanisms implemented in transport protocols; therefore a simulator called SimCast is developed for the analysis of fairness characteristics of transport protocols as well as a network traffic generator and measurement tool called SimTest. This article presents the operation and basic properties of these evaluation systems together with some simulation and measurement results. The article also presents a fairness based bandwidth control mechanism, called the Balancer method, which optimizes resource allocation of busy servers with large amount of outgoing traffic. The efficiency of this control method is presented through simulation results.

INTRODUCTION

Reliability is one of the most important features of all multimedia applications. Due to the increasing deployment of traffic lacking end-to-end congestion control, congestion collapse can arise in the Internet (Floyd, 1999, pp. 458-472). This is resulted by links, sending packets that would only be dropped later in the network. The essential factor behind this form of congestion collapse is the absence of end-to-end feedback. An unresponsive flow is failing to reduce its offered load at a router in response to an increased packet drop rate, and a disproportionate-bandwidth flow is using considerably more bandwidth than other flows in a time of congestion. In order to achieve
correct simulation of streaming media traffic, which is up to this time mostly not TCP-friendly, the effects of TCP protocol’s flow control should be determined (Postel, 1981). However, there are many different TCP and other kinds of unicast transport protocol implementations with various flow control mechanisms, which make this investigation rather difficult.

The TCP-friendly congestion control schemes in the Internet were reviewed by Wang (1981) differentiating two groups of the TCP-friendly congestion control algorithms as (a) end-to-end and (b) hop-by-hop congestion control mechanisms. The end-to-end mechanisms are grouped into (i) AIMD-based schemes (AIMD: Additive Increase Multiplicative Decrease) with window- and rate-adaptation schemes, (ii) modeling-based schemes, including the equation based congestion control schemes, and the (iii) combination of the AIMD-based and modeling-based principle. Mostly this classification is used in our discussion, too.

B. Yu (2001) proposes another important approach about the survey on TCP-friendly congestion control protocols for media streaming applications in which several TCP-friendly congestion control protocols were discussed via a comparison on many important issues that determine the performance and fairness of a protocol.

The various mechanisms implemented in different protocols are hard to compare with each other, therefore a modularly structured simulator and measurement system is developed for traffic analysis of transport layer streams (Hosszú, 2001, pp. 369-411 and Tegze 2001, pp. 66-71). To carry out performance analysis of transport layer traffic, a well usable simulation and measurement framework should be applied in order to present statistically acceptable results for transport layer data transfer. The motivation behind the development of a new, custom simulator instead of using a standard framework like ns (Breslav, 2000) was the intention to build an integrated and uniform solution for analysis of the transport layer mechanisms and the implementation of some special features. Such a feature is a traffic generator module, which uses the simulator’s protocol entities to generate real network traffic. On the one hand this allows the distributed execution of the simulator’s congestion control algorithms competing with real transport protocol implementations. In this way fairness properties of real and simulated protocols could be analyzed. On the other hand this mode of operation allows the analysis of the real physical and data link layer effects directly, while using the simulated transport layer protocols. In this way we can avoid the development of complex physical layer models, and use this hybrid method to investigate the effects of lower protocol layers on transport protocols.

Most congestion control algorithms of the Internet are reactive methods. The underlying principle of these algorithms is the closed loop control scheme of control theory. Protocol entities measure some parameters of the network and feed this information back to the sender. This feedback determinates the sending rate of participant flows. Currently most methods make use of per-flow feedback. This kind of feedback cannot give strict guarantees on fair allocation of network resources inherently. One of the most important design and operational objective of transport protocols is the fair and efficient utilization of network resources. This is the main motivation for performance analysis of transport protocols. This article presents the newly developed control method called Balancer that is developed to provide the fairer bandwidth allocation for transport layer data flows. The method is implemented in the SimCast simulation environment. The mechanism is based on the global knowledge of outgoing sending rate of controlled flows. The article demonstrates the basic properties of endpoint congestion control which is the essence of the Balancer method. We prove the efficiency of the developed method through various simulation and measurement based results. Some statistical measures of the simulated and measured protocol entities are also analyzed as well as the most important quantities of protocol