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A control theoretic approach to active queue management

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Abstract

This paper describes the Dynamic-RED (DRED) algorithm, an active queue management algorithm for TCP/IP networks. In random early detection (RED), one of the goals is to stabilize the queue lengths in routers. However, the current version of RED does not succeed in this goal because the equilibrium queue length strongly depends on the number of active TCP connections. Using a simple control-theoretic approach, DRED randomly discards packets with a load-dependent probability when a buffer in a router gets congested. Over a wide range of load levels, DRED is able to stabilize a router queue occupancy at a level independent of the number of active TCP connections. The algorithm achieves this without estimating the number of active TCP connections or flows and without collecting or analyzing state information on individual flows. The benefits of stabilized queues in a network are high resources utilization, bounded delays, more certain buffer provisioning, and traffic-load-independent network performance in terms of traffic intensity and number of connections. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: TCP; Active queue management; Random early detection; Congestion control; Control theory

1. Introduction

One problem with the TCP congestion control algorithm [1] over current drop-tail networks is that, the TCP sources reduce their rates only after detecting packet loss due to queue overflow. This is a problem since considerable time may pass between the packet drop at the router and its detection at the source. In the meantime, a large number of packets may be dropped as the senders continue to transmit at a rate that the network cannot support. Active queue management has been proposed as a solution for preventing losses due to buffer overflow. The idea behind active queue management is to detect incipient congestion early and convey congestion notification to the end-hosts, allowing them to back off before queue overflow and sustained packet loss occur. One form of active queue management recommended by the IETF for deployment in the network is random early detection (RED) [2,3]. The operations of the RED algorithm prevents problems such as traffic synchronization [4].

While RED queues certainly perform better than drop-tail queues, it is difficult to parameterize RED queues to give good performance under different congestion scenarios [8]. One of the goals of RED is to stabilize the queue lengths in routers,

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