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Improving Network Performance Through Pacing

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Abstract

The Internet is a packet switched network consisting of computers, routers and switches. The Internet is a complicated network because it needs to satisfy various functions such as flow control of connections, routing of packets and transmission of data. To simplify the design, these functions are separated through a layered architecture. In this layered architecture, each layer is responsible for different functions and each layer is independent of the other layers. Each layer is totally independent from its upper or lower layer. To understand network systems performance, one must look into flow control mechanism, which determines when and how hosts send data to each other. Flow control is provided by the transport layer in the Internet.

The Transmission Control Protocol (TCP) is the most widely used connection-oriented transport layer protocol. Recent popular applications such as WWW, e-mail, file transfers and P2P file sharing applications use TCP, which was developed in the 1970s. In 1986, the first congestion collapse in the Internet happened. Two years later a congestion control and avoidance algorithm was developed by Van Jacobson and incorporated into TCP. The algorithm comes with a penalty of under-utilization that was negligible at the time due to the network's characteristics. Years later, the delay-bandwidth product of networks has increased substantially and more bandwidth efficient solutions have become necessary.

Packet pacing, a traffic shaping technique that aims to spread packet transmissions evenly over time, has been shown to reduce the burstiness of TCP traffic. Achieving low burstiness is especially important for networks where routers use small buffers to avoid performance degradation. Previous work on packet pacing has mainly focused on TCP traffic consisting of persistent, long-lived flows. In this dissertation, we present simulation results and their analysis to explore the effects of short-lived flows in the context of packet pacing. Another concern was to understand processing delays that would be incurred by a packet pacing system. For that purpose, we implemented a packet pacer in hardware efficiently and we present our implementation. Finally, we look into how we can benefit using pacing in terms of energy savings in network systems. The last chapter of this dissertation is dedicated to a low power Ethernet

using the same idea of packet pacing.

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