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## TCP PERFORMANCE

**T**ransmission Control Protocol (TCP) is the most widely used transport layer protocol in the Internet. Most popular Internet applications, such as the Web and file transfer, use the reliable services provided by TCP. The performance perceived by users of these Internet applications depend largely on the performance of TCP. Studying the performance dynamics of TCP, therefore, becomes an essential part of designing and building high-performance TCP/IP networks.

Although the performance dynamics of TCP over traditional networks are relatively well understood, the research community is only beginning to explore the TCP performance implications for the emerging and future networking environment. The emerging networking environment has several new features which have profound performance implications for TCP-based applications. In this feature topic we present five articles dealing with the TCP performance issues and answers for the emerging networking environment.

Two striking features of future networks are wirelessness and mobility. The actual technologies supporting wireless and mobile communications may change over time, but it is now accepted that wirelessness and mobility will be part of most future communications. The questions now being asked are how TCP performs in the tetherless world and what can be done to improve the situation. In the first article, "TCP Performance Issues over Wireless Links," Xylomenos, Polyzos, Mahonen, and Saaranen examine the wireless link characteristics, outline the performance problems they cause to TCP, and then present a wide range of solutions to these problems.

Another interesting phenomenon observed with some emerging last-mile solutions, such as cable modem and ADSL, is the asymmetric network behavior in the up- and downlinks. Asymmetry can be observed in measures such as bandwidth or loss rate. Since TCP has flows in both directions, asymmetric connections can have unexpected impacts on the performance of TCP. In "How Network Asymmetry Affects Transport Protocols," Balakrishnan and Padmanabhan identify the fundamental reasons for TCP performance degradation over asymmetric networks and present several techniques to address the performance problem.

While asymmetry is a rather subtle observation of some emerging access networks, the ultra high speed is no secret of modern communication networks. Gigabit Ethernet are already being rolled out, and 10 Gb networks are on the horizon. Can the 20-year old TCP pump data at these speeds?

The third article, "End System Optimization for High Speed TCP," by Chase, Gallatin, and Yocum, explains how optimizations below and above the TCP protocol stack can allow hosts to run TCP at gigabit speed.

While some researchers are busy fine tuning TCP for high performance, we continue to see proliferation of non-TCP-based streaming media applications generating large volumes of traffic sharing Internet routers with TCP-based traffic. Since these applications do not implement TCP-like congestion control functions, they pose a real threat to TCP performance. Hong, Albuquerque, Oliveira, and Suda examine the impact of streaming traffic on TCP performance in "Evaluating the Impact of Emerging Streaming Media Applications on TCP/IP Performance."

From the above, it is apparent that TCP needs to evolve to continue as an effective transport layer protocol for the Internet. Indeed, there have been several modifications to the core congestion control algorithms in TCP. Sally Floyd wraps up this feature topic with "A Report on Some Recent Developments in TCP Congestion Control."

Before we conclude the editorial, several acknowledgments are in order. We received 22 articles for this feature topic. Over 45 reviewers worldwide helped us review them. Due to space limitations, we could only accept five articles based on the review reports. We thank all reviewers for their time and expertise, and authors of all submitted articles for their submissions to our feature topic. We also thank the former editor-in-chief, Andrzej Jajszczyk, for granting us the space in this magazine to publish the feature topic. Thanks also go to Tom Chen for acting as liaison editor for the feature topic.

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