Performance of TCP over Wireless Networks with the Snoop Protocol

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Abstract

Several attempts have been made to assess the performance of TCP over wireless networks and several solutions have been proposed to improve its performance. Even though many different TCP versions and solutions exist, so far they have not been studied together. In this paper we include a simulation-based performance analysis of the most important TCP versions over wireless networks. In addition, we analyze those TCP versions in the same environment but including the Snoop protocol and find that TCP Vegas and SACK present an opposite behavior.

1. Introduction

Wireless networks are becoming very popular and are being installed almost everywhere. However, the performance of transport layer protocols, like TCP, is hardly degraded due to very well known problems characteristic of wireless transmissions. As a result, many modifications and new solutions have been proposed to improve TCP's performance, such as forward error correction schemes, retransmissions at the link layer, split connections like M-TCP [11], Explicit Loss Notification [7], link layer TCP-Aware like Snoop [4], Performance Enhancing Proxies [5], Indirect TCP (I-TCP) [2], MAITE [1], etc.

Available performance evaluations of TCP over wireless networks are usually incomplete, meaning that the most important TCP versions and the most important solutions are not studied and compared all together. Therefore, we still don't have a good idea about what is the best combination. Here we present preliminary results in this direction including performance results of TCP Tahoe [8], Reno, New Reno, SACK [9], and Vegas [6] over wireless networks with and without the Snoop protocol. Future work will include the other relevant solutions at the link level.

2 Simulation Environment/Related Work

We use the very well-known wired-cum-wireless topology in our experiments where one station is directly attached to a router/access point through a wired network and one mobile computer is one hop away from the wireless access point. This topology was simulated using the ns-2 [10] simulator from the Lawrence Berkeley Laboratory. The system model consists of a 10 Mbps, 20 ms delay wired channel and a 2Mbps wireless channel with a negligible delay (64 micro seconds, according to the IEEE 802.11 standard). The packet size has been set to 1000 bytes and the queue size is fixed at 100. A single TCP connection is assumed from a station attached to the wired channel to a mobile computer with a maximum window size of 32 segments. The two state Markov model suggested in [12] was implemented to model the channel errors.

Various link layer mechanisms have been proposed to improve the performance of TCP over wireless channels. A complete comparison of these proposed solutions is available in [3]. However, TCP Tahoe and Vegas are not included. We chose to implement the different TCP versions over the Snoop protocol because it is one of the best performing solutions [4]. The Snoop Protocol provides a reliable solution by maintaining TCP end-to-end semantics while recovering the wireless errors locally. Snoop uses link level buffers at the base station to cache packets passing across the wireless link retransmiting unacknowledged packets and avoiding unnecessary timeouts. In addition, Snoop filters duplicate acknowledgements to avoid duplicated packets. These functions are performed by two main routines, snoop-data() and snoop-ack().

3 Simulation Results

Figure 1 shows the segments sequence numbers vs. time for all TCP versions considered over the plain wireless network. From Figure 1 we notice that except Vegas, all TCP versions perform as expected, TCP Reno being the worst and TCP SACK the best performing versions. These results are pretty well known (in particular about Tahoe, Reno and New Reno). However, we found that TCP Vegas was actually the worst of all and not many analysis are available to conclude about its behavior. We are in the process of identifying the ground causes for this behavior analyzing the

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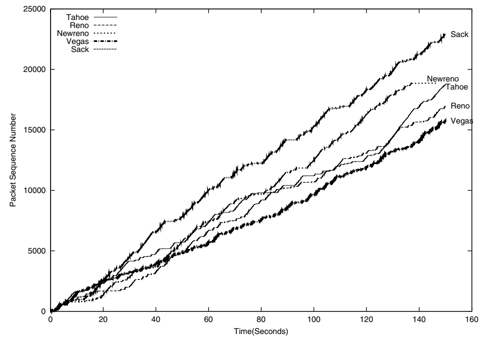

Figure 1. TCP sequence numbers vs. time for TCP Tahoe, Reno, New Reno, SACK and Vegas over wireless networks

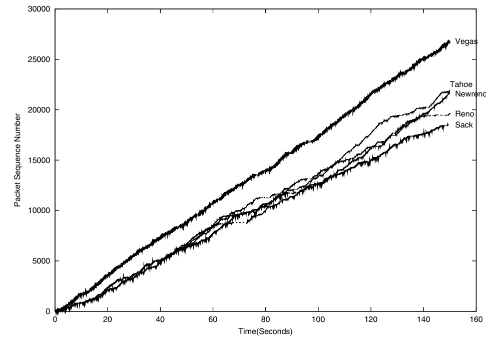

Figure 2. TCP sequence numbers vs. time for TCP Tahoe, Reno, New Reno, SACK and Vegas over wireless networks with the Snoop protocol

congestion window and how the error model affects Vegas. Initial analysis tells us that Vegas is affected more than the other TCP versions whenever the length of the error bursts is more than four packets. Looking further at this aspect, we found that this was precisely our case; 57% of the error bursts had 5 or more packets. We plan to do more experiments changing the distribution of the error burst length to verify this aspect.

We also calculated the performance of all the TCP versions as a function of the Packet Error Rate (PER). These result, not plotted here, pretty much match the results seen in Figure 1. In addition, it also shows that as the PER increases, the various TCP versions almost behave the same as they are unable to recover from the heavy loss of packets.

Figure 2 shows the TCP sequence numbers vs. time when we introduce the Snoop protocol in the base station. As expected, most TCP versions improve compared to the plain wireless environment without Snoop. For instance, TCP Tahoe, Reno and New Reno improve. However, two important aspects need further investigation. TCP Vegas, which was the worst performing version without Snoop, now is the best performing version, and TCP SACK that was the best performing version without Snoop is now the worst version. Certainly, there are unknown interactions between the snoop protocol and these TCP versions that need a more detailed investigation.

4 Conclusions and Further Research

In this short paper we present preliminary results about the performance of the most important TCP versions over wireless networks with a without the Snoop protocol. We found an interesting opposite behavior in the case of TCP Vegas and SACK that needs further investigation. We plan to complete this paper including the analysis of the most important link layer solutions, such as Snoop with delay acknowledgments and Explicit Loss Notification.

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