

# Protocol Level Solutions for Packet Reordering Problem

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## 1 Thesis Summary

The Internet is experiencing an exponential growth in users and network traffic. As the Internet grows larger and larger, the performance of the network is subjected to severe performance degrading issues such as congestion in the network, link failures, corruption of packets and reordering of packets.

In this thesis, I examined the problem of packet reordering in networks. I presented an analysis on the problem of packet reordering on networks and have presented the results. These results show the poor performance of the existing TCP protocols in the presence of packet reordering.

The following mechanisms and protocols were proposed to improve the performance of the TCP sender during the event of reordering:

In [1], I proposed a mechanism called the Explicit Packet Drop Notification Version 1.0 (EPDNv1.0) for networks that follow symmetric routing. The idea of EPDNv1.0 is to inform the sender about dropped packets in the gateway. I also proposed a mechanism, which uses the symmetric routing EPDNv1.0 to proactively detect whether a packet has been reordered in the network or not. Based on this detection, the sender delays the retransmission of the reordered packet. I termed this new protocol as Reorder Detecting TCP (RD-TCP). Performance results of RD-TCP in the presence of reordering have shown that RD-TCP outperforms the other TCP versions in the presence of packet reordering.

In [2], [3] I proposed a mechanism called the Explicit Packet Drop Notification Version 2.0 for networks that follow asymmetric routing. The idea of EPDNv2.0 is to inform the receiver about dropped packets in the gateway. I also proposed a mechanism, which uses the asymmetric routing EPDNv2.0 to proactively detect whether a packet has been reordered in the network or not. Based on this detection, the sender delays the retransmission of the reordered packet. I termed this new protocol as Reorder Notifying TCP (RN-TCP). I have presented the performance results of RN-TCP in the presence of reordering and have also shown that RN-TCP outperforms the other TCP versions in the presence of packet reordering.

In [4],[5] I incorporated minor changes to EPDNv2.0 to propose a new mechanism called the Explicit Packet Drop Notification Version 3.0 (EPDNv3.0) for satellite networks. I also proposed a new TCP protocol called TCP-R, which uses the EPDNv3.0 information received from the gateways to distinguish whether a packet has been dropped, reordered or corrupted in a error prone long delay network. If the packets are assumed to be reordered or corrupted in the network, the

TCP-R sender retransmits the packet without reducing the congestion window. I have compared TCP-R with the other TCP versions and have presented the results.

My thesis included a series of simulation experiments that show how some of these factors affect the performance of the network and prove that my proposed solutions could improve the network performance to a large extent.

## References

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- [2] A. Sathiaseelan and T. Radzik, Improving the Performance of TCP in the Case of Packet Reordering, Proceedings of the 7th IEEE International Conference on High Speed Networks and Multimedia Communications (HSNMC'04), Toulouse, France, (LNCS 3079, pp. 63-75), July 2004.
- [3] A. Sathiaseelan and T. Radzik, Reorder Notifying TCP (RN-TCP) with Explicit Packet Drop Notification (EPDN), International Journal of Communication Systems, Wiley, Volume 19, Issue 6, Pages 659 - 678, Sept 2005.
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- [5] A. Sathiaseelan, TCP-R with EPDN: Handling out of Order Packets in Error Prone Satellite Networks, International Journal of Communications, Network and System Sciences, Volume 2, Issue 7, Pages 675 - 686, October 2009.