Thesis Overview

Performance Evaluation of Multipath TCP

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There are several applications that require the data to be sent from a process running on a host to a process running on another host to be sent in a reliable manner even if the channel is unreliable. A channel is said to be unreliable if there are either bit errors or packet losses or both. In that case, the transport service needs to possess a mechanism for delivering segments from the sending process to the receiving process in a reliable manner. The mechanism often includes acknowledgements and retransmissions. The Transmission Control Protocol (TCP) incorporates such a mechanism for reliable delivery of segments between two communicating processes running on different hosts. In addition to such a mechanism, TCP provides a connection oriented service that includes mechanisms for flow control, congestion control, and in-order delivery of segments.

Some of the applications that require the data to be sent reliably over an unreliable channel also require the segments to be transported as fast as possible. These applications may include smart phones, wireless networks, peer-to-peer networks, data centers, and big data. A single path used by the traditional TCP may not be sufficient to meet the growing demands of such applications. Also, there are some applications that need a provision of Quality of Service (QoS) in terms of delay and throughput guarantees e.g. real time and multimedia applications. Using a single path, it may not be possible to provide QoS guarantees. On the other hand, there is a possibility to improve the chances of provision of QoS guarantees, if one can possibly utilize resources along more than one path between a sender and a receiver. There is a need for a mechanism that may deliver the segments possibly over multiple paths, if available, from the sending process to the receiving process running on different hosts. Multipath-TCP (MP-TCP) is version of TCP that may utilize multiple paths, if exist between two hosts, to transport segments between the communicating processes running on them.

Before deploying Multipath-TCP, it is advisable to evaluate its performance. In this thesis, we try to answer the following research question: How does Multipath-TCP perform as compared to the traditional TCP? For that purpose, we evaluated the performance of Multipath-TCP. During the performance evaluation, we focused on the following parameters: end-to-end delay, throughput, and packet delivery ratio. We evaluated the impact of link bandwidth and number of buffers in the queue on the above mentioned performance parameters.

The thesis is organized into four chapters. The first chapter contains an introduction to the work carried out in the thesis. It includes motivation, problem formulation, and literature survey. The second chapter contains an overview of Multipath-TCP. In the third chapter, we presented results and discussion. The last chapter is for conclusion and directions for future work. In what follows, we describe the contributions made in the thesis in a chapter wise fashion.

Chapter 1 contains an introduction of the work embodied in the thesis. We first described the motivation behind the thesis. We formulated the problem and described the goals of the thesis. We then presented an overview of the related work carried out by different researchers from different perspectives.

For better understanding, one should know the major goals behind the design of Multipath-TCP and services it may provide. In *Chapter* 2, we described an overview of Multipath TCP. Specifically, we described the design of Multipath-TCP and the services it may provide to different types of network applications.

In *Chapter* 3, we evaluated the performance of Multipath-TCP and compared it with the performance of regular TCP using simulations. During the performance evaluations, we focused on the following parameters: average throughput, end-to-end delay, and packet delivery ratio. We examined the effect of link bandwidth and number of buffers in the queue on the performance parameters mentioned earlier. We observe that the performance of Multipath-TCP is better in terms of the end-to-end delay and throughput as compared to the regular TCP. The reason behind this observation is that multiple paths are utilized in case of Multipath-TCP as opposed to regular TCP that utilizes only a single path for sending segments between a given sender and a receiver.

As far as, packet delivery ratio is concerned, it comes out to be almost same in both the cases. The reason for this observation is that since Multipath-TCP is a reliable transport protocol and it is also true for the regular TCP. Therefore, there is not a significant difference between the packet delivery ratio of the two protocols. However, as one may expect, the number of retransmissions in case of regular TCP are more as compared to Multipath-TCP.

Chapter 4 contains conclusions and directions for future work. We conclude that the performance of Multipath-TCP is better as compared to the regular TCP in terms of average throughput and average end-to-end delays. Multipath-TCP has a potential for delay sensitive applications and for improvement of chances for providing QoS guarantees for real time and multimedia applications. We carried out the performance evaluation of Multipath-TCP using simulations. In future, one may consider to develop a test bed for experimentation with Multipath-TCP on a Linux kernel. One may also analyze correlation or dependencies among the delays and throughput if multiple paths between a given source and a destination are not completely independent.

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