Countermeasures to Impacts of Bandwidth and Receiving Buffer on CMT Schemes

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Abstract

Based on the impact investigation of both bandwidth and receiving buffer on concurrent multi-path transmission (CMT) schemes of Stream Control Transmission Protocol (SCTP), the authors present an adaptive policy on how to effectively apply CMT-SCTP schemes under various network conditions. Moreover, an optimal fast SACK (FACK) scheme is proposed too in this paper in order to accelerate the feedback of SACKs and further find out varieties of both available bandwidth and loss rate as soon as possible. Simulation results show that the proposed scheme could improve the traffic efficiency of the CMT scheme when receiving buffer is bounded and network bandwidth gets smaller.

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1. Introduction

With the common of multi-interface’s computer equipments in general, the issues on concurrent multi-path transport (CMT) are becoming hot for research field, which can improve throughput performance via aggregating the bandwidths of multiple unoverlap paths between the end-to-end multihoming hosts.

Notice that CMT can be performed at multiple layers; however, the transport layer can have the most accurate information about end-to-end delays as well as reordering at receiving buffer. Thus CMT is desirable to be implemented at the transport layer. For example, when CMT-SCTP [2] is applied between two multihomed peers over a bandwidth-limited network, its cwnd evolution can exceed the sum of cwnd evolutions of two independent SCTP runs over the independent data paths [2]. Such a prominent report has not been seen in the other literatures up to now.

It is also noted that reordering is a natural consequence of CMT. It is difficult to be eliminated in an environment where the end-to-end path characteristics are changing or unknown, as in Internet. Thus CMT can lead to some problems resulted from different path delays, such as unnecessary fast retransmissions, reduced congestion window (cwnd) growth, increased SACK/ACK traffic and receiving buffer blocking problem [2-9] which usually causes throughput degradation during multi-path transfer.

Moreover, bandwidth is another important impact factor for the performance of CMT schemes, and generally only narrow bandwidth networks, such as wireless network, are available for them. Nevertheless, thus far not sufficient studies from this perspective have been done. This paper studies the performance of CMT-SCTP [8] with variable bandwidth as well as receiving buffer so as to find out the relationship between CMT performance profits and available bandwidth as well as receiving buffer.

Simulation results show that compared to the normal SCTP, the performance profit of CMT-SCTP strongly depends on network bandwidth when the receiving buffer is bounded. The rest of this paper is organized as follows. Section 2 briefly introduces some related works. Section 3 presents the countermeasure to impacts of bandwidth and receiving buffer on CMT schemes and we conclude this paper in section 4.

2. Related Works

CMT-SCTP [2] is a typical CMT scheme, which shares sequence space among flows on different paths of an association. The simulation result with two independent paths show that the cwnd evolution of the scheme is as close to the sum of the cwnd evolutions of two independent SCTP runs as possible. The result reports the best simulation results so far, compared to other CMT schemes.

Janardhan R. Iyengar et al also studied the performance of CMT scheme in the presence of a bounded receive buffer (rbuf) [9]. They found that if two paths are used for CMT, the lower quality (i.e., higher loss rate) path degrades overall throughput of an rbuf-constrained CMT association by blocking the rbuf. They argued that rbuf blocking is not specific to the transport layer, but applies to multipath transfers at other layers as well. They drew a conclusion that when large differences exist in path delays and loss rates, using only the better path outperforms using two paths concurrently. While rbuf blocking cannot be eliminated, it can be reduced by choice of retransmission policy—a mechanism available to only the transport layer.

On the other hand, in [11] we investigate the performance profit of CMT schemes based on the CMT-SCTP model provided in ns2.30 [10] since the CMT-SCTP [2] reports the best simulation results. Simulation results demonstrated that when bandwidth is large enough (e.g., bandwidth > 10M), the throughput performances of both CMT and normal schemes are almost the same. Whereas, when the bandwidth gets smaller, the performance degradation of the normal SCTP is significantly violent, compared to that of the CMT scheme. For example, when bandwidths are limited (e.g., bandwidth < 2
Mbps), CMT scheme can fully play its advantage. Thus, the CMT schemes can be used to significantly improve transmission efficiency of wireless networks.

3. Proposal and Simulations

Based on our simulation studies [11] and the research results reported in [9], we can conclude that 1) the narrow bandwidth links (e.g., available bandwidth < 2 Mbps) are more available for CMT schemes than those of broad band ones; 2) CMT schemes cannot always outperform the typical SCTP [1] (e.g., available bandwidth > 10 Mbps); 3) if two paths are used for CMT, the lower quality (i.e., higher loss rate) path degrades overall throughput of an rbuf-constrained CMT association by blocking the rbuf; 4) rbuf blocking is not specific to the transport layer, but applies to multipath transfers at other layers as well; 5) when large differences exist in path delays and loss rates, using only the better path outperforms using two paths concurrently.

Therefore, we argue in this paper that an adaptive policy should be applied for the multihomed hosts with CMT schemes in the face of a complex network environment, such as dynamic variable path delays and loss rates. In particular, if available bandwidths are less than a certain value (e.g., 5M bps) and loss rates are not high, the CMT should be performed; otherwise, instead of the normal SCTP. In the same way, once loss rate is measured too high, the normal SCTP should be chosen too.

Moreover, in order to accelerate the feedback of SACKs, we proposed a fast SACK (FSACK) mechanism for CMT schemes so as to find out the changes of both delay and loss rate as soon as possible. In the scheme the multihomed end hosts periodically detect the one-way-delays of all available reverse paths and select the lowest delay’s one as the current SACK path. At the same time, the sender insists on monitoring one-way-delay’s variation of the current SACK path. Once the one-way-delay of the current SACK path becomes larger than that of the other path, the sender will ask the receiver to distribute SACKs over all reverse paths in turn again in order to find out the newly optimal SACK path.

Integrating the adaptive policy and the FSACK mechanism into a new solution, we can overcome impacts of bandwidth and receiving buffer on CMT schemes. The disadvantage of the new solution is that the formats of both data and SACK chunks need revisions. For data chunk, a one-byte field is appended, which will be filled with the sequence number of the current optimal SACK path by the sender. For SACK chunk, three additional fields are appended. The first is a four-byte one-way-delay field, which is used by the sender to calculate the most recent one-way-delay of the SACK’s actual path. The second is a one-byte field which will be filled with the sequence number of the destination address from which the SACK is sent actually. The third is a one-byte field which will be filled with the sequence number of the destination address where a data segment triggers this SACK to arrive at the receiver side.

When a SACK arrives at the sender side, the sender assume that the SACK is sent from the destination address which is indicated by the third additional field of the SACK chunk but in spite of the actual

Fig. 1. Simulation topology
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SACK path, and sends data segment towards it at first if only the rwnd allows. In such case, although using one reverse path to send SACKs dynamically will cause asymmetry of some forward and reverse paths, it will not influence each connection’s normal operation.

We develop the simulation model based on the modification of CMT-SCTP model provided in ns2.30 because the CMT-SCTP [2] reports the best simulation results. The simulation topology as shown in Fig. 1 is simple. We chose such a simple topology to avoid influence of other effects, and to focus on performance differences which we believe should hold true in a real environment as well. In Fig. 1, the core links represent the end-to-end conditions in the Internet. In particular, both links have the capacity of 2Mbps and the propagation delay of 45ms on the forward and reverse paths. The absolute bandwidths were chosen to be sufficiently low so that SACK path’s delay is easily influenced, and the end-to-end delay was chosen as 45 ms to represent a typical U.S. coast-to-coast delay. Moreover, the initial slow start threshold (initialSsthresh) is set to 16000 bytes, each node has a fixed length’s queue whose size is 50 packets and each data chunk has a fixed size of 1468-byte. That is, the main simulation parameters were set based on the script function of sctp-cmt-2paths-64K provided in test-suite-sctp.tcl of ns2.30.

In all experiments, we assumed that both multihomed sender and receiver decided to choose CMT-SCTP due to a limited bandwidth, based on the adaptive policy. And we only focus on the profits of the FSACK mechanism, but not the impact of the retransmission policy like CMT-SCTP. Therefore, we do not introduce any additional loss model, and all packet losses are assumed to be caused by network congestions.

In particular, we applied an infinite TCP background traffic with the fixed segment size of 1460-byte over the upper link’s reverse path so that the SACKs’ propagation delays are often changed with the variation of the congestion extent of that path. Fig. 2 depicts the TSNs of the data chunks received by the receivers. In the figure, we notice that performance of the proposed scheme is best because the majority of SACK chunks can flow along the shorter delay’s reverse path. On the other hand, the sooner SACK chunks accelerate sending rate of data chunks in fact. As a result, the total data chunks received by a FSACK receiver are much more than those of other schemes.

Fig. 2. Traces of TSNs received by receivers with reverse traffics along both links
4. Conclusions

In this paper, we reviewed the performance profit of CMT-SCTP with various network environments (e.g., bandwidth, loss rate, receiving buffer, etc.) and pointed out that the CMT schemes may only play their advantage in the narrow band networks with bounded receiving buffer and lower loss rate. Therefore, an adaptive policy should be available in order to dynamically apply CMT-SCTP depending on network condition strongly. We also proposed a fast SACK mechanism in this paper to accelerate feedback of SACKs in CMT environments so as to find out the changes of available bandwidth as well as loss rate as soon as possible. Simulation results also show that the proposed scheme can improve the traffic efficiency of the CMT schemes. Although an adaptive policy is a feasible solution, there are still a lot of studies to be needed on how to effectively use CMT SCTP schemes.

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