PERFORMANCE EVALUATION OF SCTP IN MOBILE AD HOC NETWORKS

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I. INTRODUCTION

Mobile ad hoc networks with their unique infrastructure-less feature continue to receive more and more attentions in the vehicular technology area. Applications in such network such as time-critical safety messages or other mobile e-commerce or multimedia applications require a reliable transport layer protocol. Other than TCP, SCTP is an emerging general-purpose transport protocol for IP network communication. SCTP was originally proposed for the PSTN signaling messages across the IP networks. However, with the multi-homing and the multi-streaming features, SCTP gradually becomes popular for use by the Internet applications. Since MANET has very different characteristics from wired networks, it is important to evaluate the performance of SCTP over MANET. Several papers including [1], [2] have studied certain behaviors of SCTP in MANET and presented performance comparisons between TCP and SCTP. Due the complexity and variety of MANET and the development of SCTP, such effort has not been completed. Meanwhile, the simulation results presented in those papers were obtained from the ns-2 network simulator. Different from their work, we have developed a comprehensive SCTP simulation model using the QualNet simulator [3]. By using the developed SCTP model and the QualNet simulator, this paper investigated the performance of SCTP over MANET. Section II presents the simulation environment, and results are presented in Section III along with explanations of certain results. Section IV concludes the paper. Due to the page limitation, the comprehensive performance evaluations and comparisons under different settings will appear in the full paper.

II. SIMULATION ENVIRONMENT

The simulation results for this paper were obtained from the QualNet simulator. In the simulation, 50 nodes are randomly deployed in an area of $1500 \times 1500 m^2$. The transmission range of each node was set to 250m. Random Way Point movement model was used to simulate the mobility of nodes. AODV routing protocol was used. The MAC layer protocol was the standard IEEE802.11 with bandwidth of 1Mbps. Since TCP and SCTP have different header length, we used 1340 bytes as data payload for both TCP and SCTP. The initial congestion window (`cwnd`) for SCTP is 4380 bytes according to [4]. A generic application was used to create the traffic between node 1 and node 50. The application started 10 seconds after the simulation was initiated and continued the transfer of a multimedia document containing independent objects[1] till the end of the simulation. The simulation time was 900 seconds.

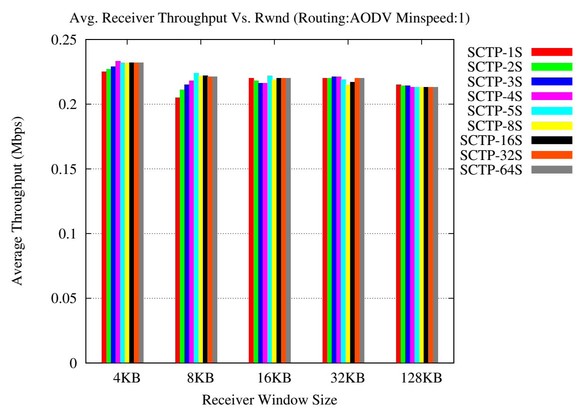

Fig. 1. Impact of multi-streaming and receiver window size

III. PERFORMANCE EVALUATION

III-A. Impact of streams

Due to strict ordering in the transfer of independent objects, TCP suffers from head of line blocking. Such problem is more severe when the receiver only has a small buffer size. SCTP can alleviate this problem by using multiple streams where independent objects are transferred in separate streams. If there is a packet loss in one stream, other streams without packet loss can still be able to deliver ordered packets to upper layer and spare the space in receiver buffer for incoming packets. If the sending rate is

[1]Independent objects might be content-dependent but they can be transferred separately without violating causality.

bounded by the receiver window (`rwnd`) not the congestion window (`cwnd`), a larger advertised value of `rwnd` can certainly imply a higher sending rate; hence, the throughput is improved.

Fig.1 depicts the various throughputs with different number of streams and different size of receiver windows under low mobility case with the speed range $[1, 2]$ m/s. When the receiver window is 4KB and 8KB, larger number of streams such as 8 and 16 streams generates higher throughput than lower number of streams such as 1, 2, and 3 streams. However, with the increasing of the receiver window size, such advantage of multiple streams disappears. The reason is clear: larger receiver buffer can accommodate more out-of-order packets. Then the `rwnd` is no longer the constraint of the sending rate.

III-B. Impact of receiver window size

Given the same number of streams and different receiver window sizes, it is interesting to observe in Fig.1 that the throughput with 4KB receiver buffer is slightly better than with larger receiver buffer sizes. It may come against the intuition: larger receiver buffer at least should not worsen the throughput. We found that the simulations with larger buffer size generated more retransmission events than with 4KB buffer. Therefore, the `cwnd` fluctuated heavier in those larger receiver buffer cases and the traffic became more bursty. In contrast, in the case of 4KB receiver buffer size, the `rwnd` bounded the sending rate from large fluctuation. The sending rate became much smoother and eventually higher throughput is obtained.

III-C. Comparing SCTP with TCP

Since SCTP uses almost the same congestion control mechanisms as used in TCP NewRENO/SACK, the performances of the two should be similar if multi-homing is not used in SCTP. However, SCTP has some features that could make it generate lower throughput than TCP.

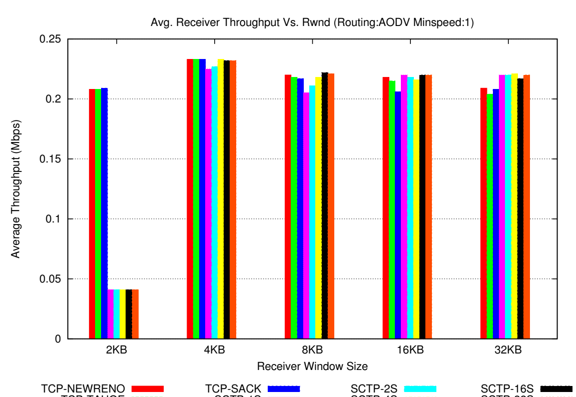

Fig. 2. Throughput: SCTP vs. TCP

(1) Size of SCTP Header. In comparison with TCP's 20 bytes header (without optional field), SCTP has 12 bytes common header plus chunk header(s). For example, the data chunk header has 16 bytes. If only one data chunk is considered, then SCTP has 28 bytes header, which is 40% larger than TCP header.

(2) Size of Selective ACK. SCTP defines a special chunk, SACK Chunk, as the way to report the gaps in the received data. SACK chunk has a relatively large size compared to TCP SACK. For example, if there is no gap observed in the received data, SCTP SACK still needs 28 bytes, but TCP SACK only needs 20 bytes as acknowledgement. By combining the expense in SCTP header and SCTP SACK, it should not come as a surprise that TCP throughput can be better than SCTP. Our simulations showed that the TCP throughput with different versions (NewRENO, Tahoe, SACK) are a bit higher than SCTP when the nodes are almost static. But with the increasing of nodes' mobility, it is hard to see such advantage of TCP over SCTP. Figure 2 with the speed range $[1, 2]$ m/s shows SCTP has very similar performance to TCP (except the case of 2KB).

(3) Message based vs. byte based transmission. SCTP transmission is message-based, which means the chunk is the basic unit for transmission, not the byte. TCP transmission is byte-based. As observed in Figure 2, TCP performance is much better than SCTP in the case of 2KB receiver buffer. Given such a small receiver buffer and each SCTP data chunk has 1340 bytes of payload, SCTP can not send out the next chunk until the previous one has been ACKed. Thus, 2KB buffer can not be fully utilized. There is always 660 bytes free space. On the other hand, since TCP is byte-based, it can fully utilize the receiver window.

IV. CONCLUSION

The results presented in the previous section show that SCTP and TCP have similar throughput in MANET; multi-streaming can help SCTP reduce the head-of-line blocking if the receiver buffer is tightly limited; relative small receiver window can bound the sending rate from jumping dramatically. More SCTP performance evaluation and comparison with TCP will appear in the full paper.

V. REFERENCES

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