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Adaptive Primary Path Switching for SCTP Handover

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***Abstract* — This paper proposes a primary path switching scheme for SCTP handover, in which a mobile terminal switches its primary path to an alternate path adaptively by using the round trip times (RTTs) of the paths measured in the network. From the experiments we see that a conservative switching scheme is preferred in the network where the gap of RTTs of the candidate paths is small, whereas an aggressive scheme is reasonable in the network with a large gap of RTTs.**

***Keywords* — SCTP, Handover, Primary Path, Switching, RTT**

1. Introduction

The Stream Control Transmission Protocol (SCTP) [1] can be used to support the handover of a mobile terminal (MT) in the transport layer by using the multi-homing feature [2].

Fig. 1 sketches the SCTP handover of an MT that moves across two wireless access networks. When the MT is in the overlapping region of the network, it can use the two different paths: *primary* and *alternate*. For SCTP handover, the MT will determine its primary path by considering the network conditions such as round trip time (RTT) or signal strength of the wireless links.

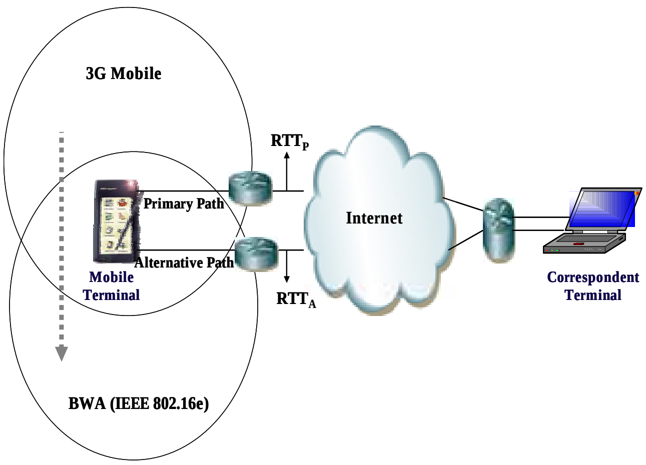


Fig. 1. SCTP handover in the mobile networks

One of the challenging issues on SCTP handover is to determine when an MT should switch the primary path to another alternate path while it is in the overlapping region. A study [3] proposed to compare a relative ratio of RTTs of the primary and alternate paths. In the study, it is suggested that the primary path should be switched to an alternate path only if the RTT of the current primary path (RTT_P) is greater than the RTT of an alternative path (RTT_A); that is, if $RTT_P > \alpha\, RTT_A$, where α is a fixed constant (e.g., $\alpha = 3$) and called 'switching coefficient' for primary path switching.

This paper addresses the primary path switching for SCTP handover in the mobile networks. We propose a new primary path switching scheme which is based on the 'absolute gap' of RTTs ($|RTT_P - RTT_A|$) as well as the 'relative ratio' ($RTT_P \geq RTT_A$). In the proposed scheme the switching coefficient is adaptively configured, based on the network conditions that are represented by the absolute gap of RTTs. The proposed primary switching scheme will be evaluated for SCTP handover in a variety of network environment.

The rest of this paper is organized as follows. Section 2 describes the proposed scheme of the adaptive switching of SCTP. In Section 3, we analyze the performance of the proposed scheme over the Linux testbed. Finally, Section 4 will conclude this paper.

2. Proposed Scheme

In the viewpoint of throughput performance, the SCTP primary path switching scheme should be designed by considering the following two factors:

1) RTT: the path with a small RTT gives better throughput
2) *cwnd*: the SCTP congestion window will be reduced by switching the primary path, which degrades throughput.

Let us consider the switching rule, "the primary path is switched to the alternate path, if $RTT_P > \alpha\, RTT_A$." In terms of the first RTT factor, a smaller α is preferred, which ensures that an MT uses the primary path with a shorter RTT. However, this may incur too much frequent switching of primary path and thus result in the degradation of SCTP throughput. This is because the primary path switching will enforce the SCTP congestion control to enter the slow-start mode on the new primary path.

In terms of the second *cwnd* factor, a larger α is preferred. The large α will prevent the primary path from being switched too much frequently. Accordingly, we need to consider the trade-off relationship between RTT factor and *cwnd* factor in the design of the SCTP primary path switching scheme. The choice of a suitable α may give a significant impact on the throughput of SCTP handover.

Based on the description given above, we suggest a new adaptive scheme for primary path switching, which employs the two different rules for primary switching, *conservative* and *aggressive*, based on the absolute gap of the measured RTTs for the primary and alternate paths in the network.

In the proposed scheme, the conservative rule is used with a larger α, when the absolute gap of RTTs is relatively small, whereas the aggressive rule will be used with a smaller α, when the absolute gap of RTTs is large. That is, the primary path will be conservatively switched in the networks where the gaps of RTTs for the primary and alternate paths are small, so as to avoid the unnecessarily frequent primary switching events. In the opposite case, the primary path will be switched aggressively to exploit the path with a shorter RTT.

Let α_1 and α_2 be the switching coefficients that are used to compare the relative ratio of RTTs (we assume $\alpha_1 > \alpha_2$). We also define β (e.g., β=1 second) as a preconfigured threshold that is used to determine which rule should be used for primary switching, *conservative* or *aggressive*. Then the proposed SCTP primary path switching scheme can be summarized as follows:

Conservative Rule: when $|RTT_P - RTT_A| \leq \beta$,
If $RTT_P > \alpha_1 \cdot RTT_A$, then the primary path is switched to the alternate path.

Aggressive Rule: when $|RTT_P - RTT_A| > \beta$,
If $RTT_P > \alpha_2 \cdot RTT_A$, then the primary path is switched to the alternate path.

3. Numerical Results

To evaluate the performance of the proposed primary switching scheme, we construct a small test network using the LK-SCTP [4] and NISTNET emulator [5].

On the testbed, the two SCTP hosts (an MT and a fixed host) communicate each other. The NISTNET emulator is used to emulate the variations of RTTs between the two end hosts in the network. In the experiment, the MT continues to move across the two neighboring areas in the overlapping region with a random 'ping-pong' movement pattern, as illustrated in Fig. 2.

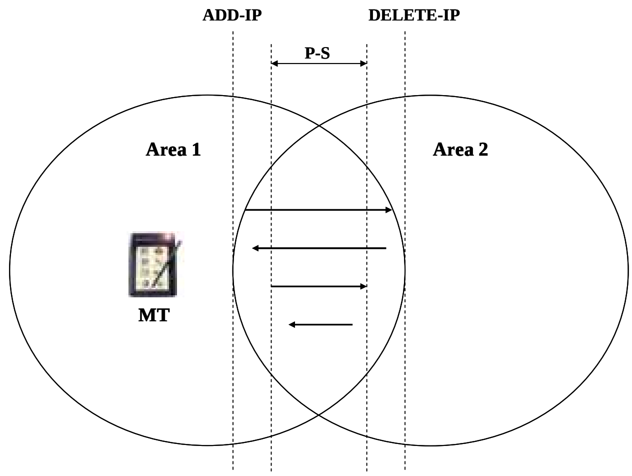


Fig. 2. Ping-pong movement pattern for an MT

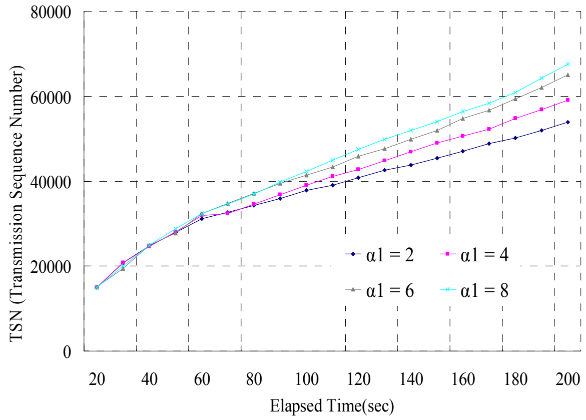
In the figure the MT moves around in the overlapping region with irregular movement directions. The MT will perform the SCTP handover operations: ADD-IP, Primary Switching (P-S), and DELETE-IP [1].

For experiment, we configured the two types of networks. The first network is configured in which the gaps of RTTs for the two paths are small (less than 1 second), whereas the second network is with the large gaps of RTTs (ranged from 1 to 9 seconds). The first type of network can be regarded as the handover scenario in which an MT moves between the two homogeneous access networks with similar network characteristics (e.g., bandwidth and delay), whereas the second network considers the handover case in which the MT moves across the two heterogeneous access networks with different network features.

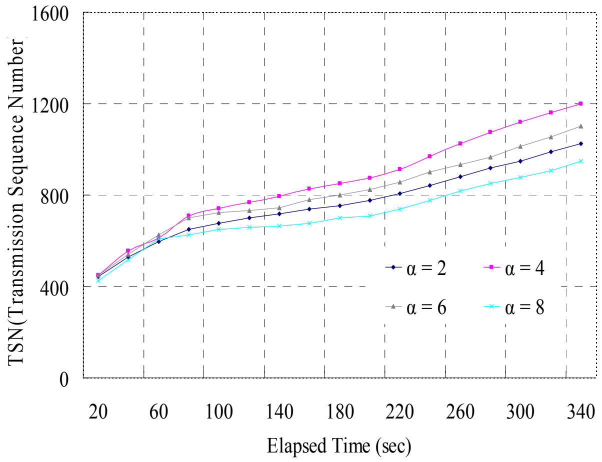
Fig. 3 compares the throughput of SCTP for the two test scenarios, in which Transmission Sequence Number (TSN) values are plotted for the SCTP data chunks exchanged between the two hosts, as the elapsed time goes on.

Fig. 3(a) shows the results in the test network with small RTT gaps. In the figure, SCTP throughput gets better for a larger α (e.g., α = 8), which implies that the 'conservative' switching rule is preferred so as to avoid the frequent primary path switching. In this case, it seems that the *cwnd* factor gives more significant impact on the SCTP throughput, compared to the RTT factor.

Fig. 3(b) shows the results for the test networks with the large absolute gaps of RTTs. In the figure, we see that the experiment with α = 4 gives the best throughput, not the case with α = 2 or 8. This implies that there exists a suitable α for optimizing the SCTP throughput from the trade-off relationship between RTT factor and *cwnd* factor. That is, we need to consider the aggressive primary path switching rule in the networks where the gap of RTTs is large.



(a) Results in networks with small RTT gaps



(b) Results in networks with large RTT gaps

Fig. 3. Throughputs of SCTP handover for different switching coefficients

From the results, it seems that the conservative scheme is preferred for primary path switching in the case that the gaps of RTTs are relatively small, whereas the aggressive scheme needs to be considered when the gaps of RTTs are relatively large.

On the other hand, Fig. 4 shows the result for another integrated test network where the absolute gaps of RTTs are ranged from 0 second to 9 second (that is, this experiment includes both the cases with large and small RTT gaps). For the experiment, we employed the two switching coefficients differently: α_1 (when the RTT gap is lower than 1 second) and α_2 (when the RTT gap is greater than 1 second).

In the figure, we see that the case with $\alpha_1 = 9$ and $\alpha_2 = 3$ gives the best throughput, whereas the case with $\alpha_1 = 3$ and $\alpha_2 = 9$ gives the worst performance. In particular, it is noted that the adaptive scheme with a larger α_1 for small RTT gap and a smaller α_2 for the large RTT gap provides better performance than the existing scheme using the identical value for α_1 and α_2 (e.g., $\alpha_1 = \alpha_2 = 3$ or 6).

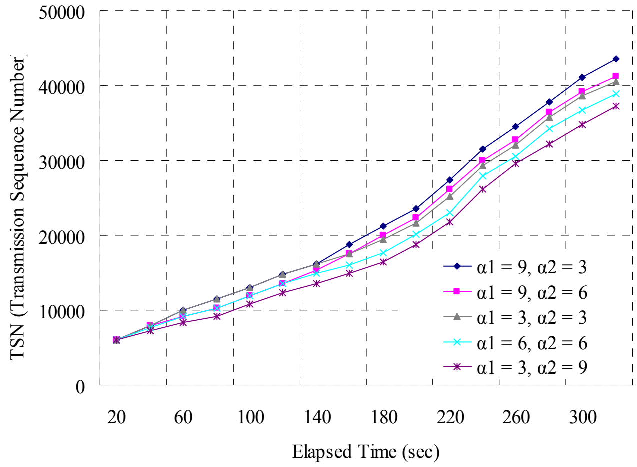


Fig. 4. Throughputs of the proposed scheme in the integrated networks

From the result, we can see that an RTT-based primary switching scheme for SCTP handover needs to use different switching coefficients, adaptively to the network conditions represented by the absolute gaps of the RTTs for the current primary and promising alternate paths.

4. Conclusions

In this paper, we propose an adaptive scheme of the primary path switching for SCTP handover, which is based on the absolute gap and relative ratio of RTTs measured for the primary and alternate paths. From the numerical results, it seems that a conservative scheme is preferred in the network where the gaps of the measured RTTs are small, whereas an aggressive scheme can be used in the network where the gaps of RTTs are relatively large.

Acknowledgement

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