mSCTP for Soft Handover in Transport Layer

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***Abstract*—In this letter, we discuss mobile Stream Control Transmission Protocol (SCTP) for soft handover in the transport layer. From the experimentations on triggering rules for Add-IP and Primary-Change during the handover, it is shown that the *aggressive* Add-IP and *conservative* Primary-Change rules provide better throughput.**

***Index Terms*—Handover, IP mobility, Stream Control Transmission Protocol (SCTP), transport layer.**

I. Introduction

STREAM Control Transmission Protocol (SCTP) [1] is a new reliable transport protocol located at the side of Transmission Control Protocol (TCP) and User Datagram Protocol (UDP). Differing from TCP and UDP, the SCTP is featured by 'multi-streaming' and 'multi-homing'. In particular, the multihoming feature of SCTP enables SCTP to be used for Internet mobility support, without support of network routers or special agents.

The recent works on SCTP include the so-called *ADDIP extension* [2]. The ADDIP extension enables an SCTP endpoint to add a new IP address or delete an unnecessary IP address, and also to change the primary IP address used for the association, while an SCTP association is active. When one of the events such as ADD, DELETE, and CHANGE occurs during an association, the SCTP endpoint will notify the corresponding event to the remote endpoint by sending an SCTP ASCONF (Address Configuration Change) chunk.

In this paper, we discuss "mobile SCTP (or mSCTP for short)", defined as an SCTP implementation with its ADDIP extension, for supporting soft handover in the transport layer. With mSCTP, each endpoint is now able to add or delete an IP address to or from the existing association, and also to change the primary IP address for SCTP association. We also show some experimentation results based on ns-2 simulator, which are done for the performance comparison of the different triggering rules of adding a new IP address and changing the primary IP address for the on-going SCTP association [3].

II. Soft Handover Procedures

In this section, we describe how to use mSCTP for soft handover in the transport layer. For an example, we consider a mobile node (MN) that initiates an SCTP association with a correspondent node (CN) in IPv6 networks. The case in IPv4 has similar procedures as those in IPv6 networks. After initiation of an SCTP association, the MN moves from access router A to access router B, as shown in Fig. 1.

It is assumed that an MN initiates an association with a CN. The resulting SCTP association consists of IP address 2 for MN and IP address 1 for CN. Then the procedural steps described below, from Step 1 through 4, will be repeated whenever the MN moves to a new location, until the SCTP association will be released.

Step 1) *Obtaining an IP address for a new location*: Let us assume that the MN moves from AR A to AR B and thus it is now in the overlapping region. In this phase, we also need to assume that the MN can obtain a new IP address 3 from the AR B by using IPv6 stateless address configuration.

Step 2) *Adding the new IP address to the SCTP association*: After obtaining a new IP address, the MN's SCTP informs the CN's SCTP that it will use a new IP address. This is done by sending an SCTP ASCONF chunk to the CN. The MN receives the responding ASCONF-ACK Chunk from the CN.

Step 3) *Changing the primary IP address*: While the MN further continues to move toward AR B, it needs to change the new IP address into its primary IP address according at an appropriate rule. Actually, the configuration of a specific rule to trigger this "primary address change" is a challenging issue of the mSCTP.

Step 4) *Deleting the old IP address from the SCTP association*: As the MN progresses to move toward AR B, if the old IP address gets inactive, the MN must delete it from the address list. The rule for determining if the IP address is inactive may also be implemented by using information from the underlying network or physical layer.

III. Simulation on Triggering mSCTP Handover

The performance of mSCTP handover will depend on how to configure the triggering rules for 'adding a new IP address' (Add-IP) and 'changing the primary IP address' (Primary-Change) to an on-going SCTP association. We have analyzed the performance of different triggering rules during the mSCTP handover by using the ns-2 code of SCTP [4].

A. Test Environments

To perform the ns-2 simulations, a test environment is configured with a CN located in the wired network and an MN moving between two wireless cells, as shown in Fig. 2. In the test net-

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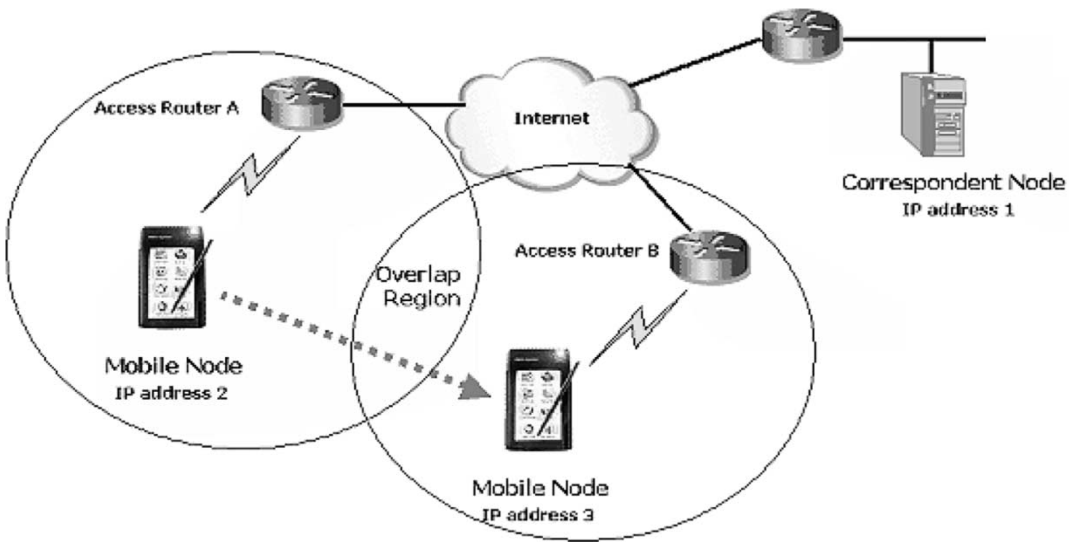

Fig. 1. mSCTP soft handover.

works, the wired links have the link bandwidth of 10 Mbps and transmission delay of 15 ms, whereas the wireless links are of the link bandwidth of 2 Mb/s and transmission delay of 1 ms. It is also configured that each cell has the wireless coverage with the radius of 190 m and also the overlapping region is of 80 m between those two cells.

In test simulations, the MN establishes an SCTP association with the CN and then moves between the two neighboring cells. After SCTP initiation, the MN starts to download a file with the size of the 32 Mbytes from the CN. To measure the mSCTP performance, we employed the overall throughput for data transport. That is, we measured the totally elapsed time for MN to download the 32 Mbytes file completely from the CN via an SCTP association, which is denoted by "file delivery time (in seconds)" in the paper. A lower delivery time will represent a higher throughput in the experimentations.

In addition, the following parameters are configured for mSCTP handover:

- MN's speed $= 20$ m/s;
- number of handovers experienced by $\mathrm{MN} = 4$;
- wireless signal strengths for detection of a "beacon" message from $\mathrm{AR} = 1.5 \times 10^{-11}$;
- wireless signal strengths for triggering an Add-IP event $= 3.6 \times 10^{-10}$ (which is equivalently set to the minimum signal strength required for data transport);
- exponential error model (with an average of 5% loss probability) given by ns-2.

For the analysis of the performance impacts on the different triggering rules for "Add-IP", we applied the following two different triggering rules:

- Aggressive Add-IP: a new IP address is added to the association only if the associated wireless signal strength is greater than the Add-IP criteria (i.e., 3.6×10^{-10}).
- Conservative Add-IP: a new IP address is added to the association if its wireless signal strength is greater than that those for the current IP addresses.

In either case, IP address will be deleted from the association if the signal strength is lower than the Add-IP criteria.

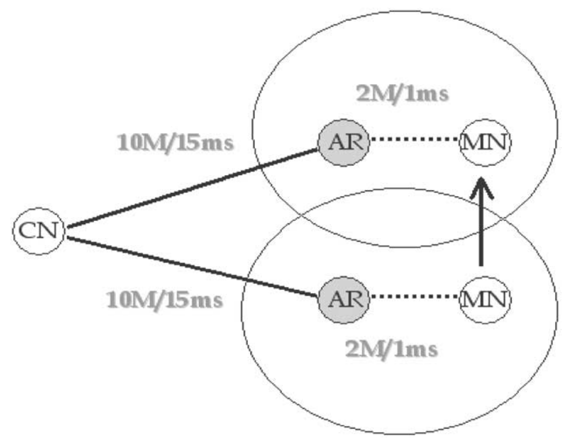

Fig. 2. Test networks.

Two different threshold values of the wireless signal strengths for triggering "Primary-Change" are applied. For each case, the current primary address is changed to the other address (which has the best signal strength among the candidates), if its signal strength becomes lower than the following threshold values:

- Aggressive (or higher) threshold for triggering "Primary-Change" $= 6.8 \times 10^{-10}$;
- Conservative (or lower) threshold for triggering "Primary-Change" $= 4.7 \times 10^{-10}$.

B. Numerical Results

For the performance analysis of mSCTP handover, we measured the overall throughput (i.e., the file delivery time) under two different mobility patterns such as "cross-over" and "random", as illustrated in Fig. 3.

As shown in the figure, in the crossover mobility pattern, the MN moves regularly between two cells, hence there is no ping-pong effect. On the other hand, in the random mobility pattern it moves randomly without any restriction, which possibly induces a ping-pong effect.

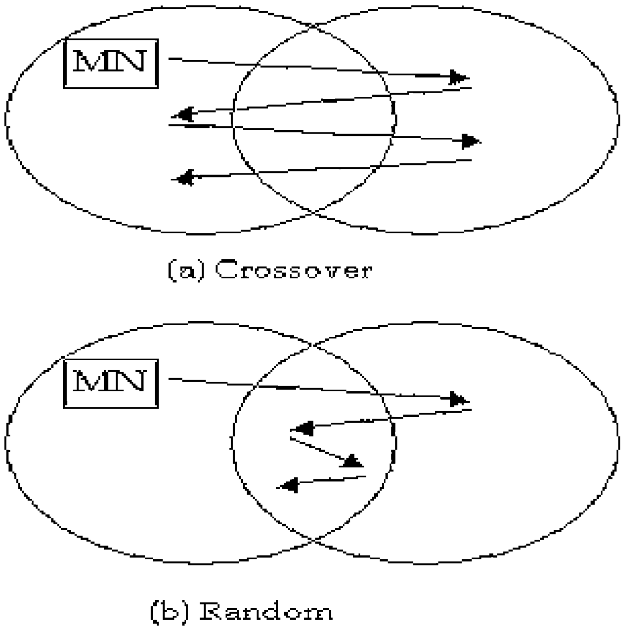

Fig. 3. Mobility patterns.

For each mobility scenario, we compare the file delivery time for the following four instances by combining two different Add-IP rules with two different Primary-Change rules:

1) Aggressive Add-IP with Aggressive Primary-Change;
2) Aggressive Add-IP with Conservative Primary-Change;
3) Conservative Add-IP with Aggressive Primary-Change;
4) Conservative Add-IP with Conservative Primary-Change.

Figs. 4 and 5 show the performance comparisons for the test scenarios. Each numerical value represents the result that was averaged for the totally 40 ns-2 simulation runs. Fig. 4 shows the comparison of the mSCTP performance in the crossover mobility patterns, while Fig. 5 gives the performance evaluation for the random mobility pattern.

It is noted that the performance gaps between the test scenarios are not significant, which may be due to the small test environments. However, we can see a specific trend of the performance for different combinations of the triggering rules. Overall, it is seen that the aggressive Add-IP with conservative Primary-Change rule provides better performance than any others.

In the viewpoint of the Add-IP rules, the aggressive Add-IP rule is preferred to the conservative one. This is because the utilization of the secondary IP address gets higher, as an additional IP address is earlier registered with the SCTP association by Add-IP operation. The file delivery time will be much more reduced by using the backup IP address earlier.

In the viewpoint of the Primary-Change rules, it seems that the conservative rule gives slightly better performance than the aggressive one. It means that the aggressive Primary-Change rule induces more frequent changes of the primary IP address and thus the SCTP transport behavior becomes unstable, hence the file delivery performance is degraded.

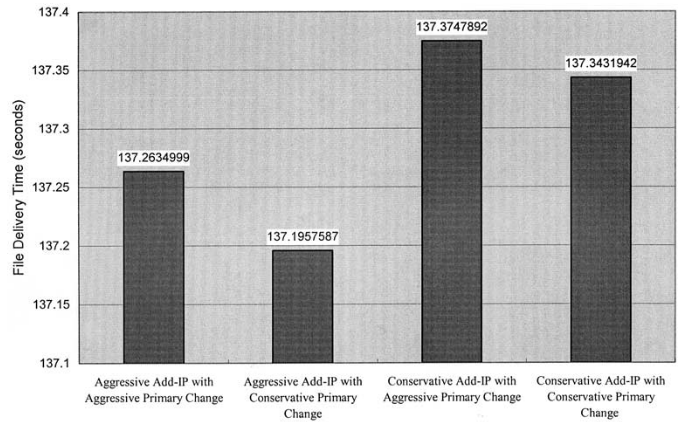

Fig. 4. mSCTP performance in the cross-over mobility pattern.

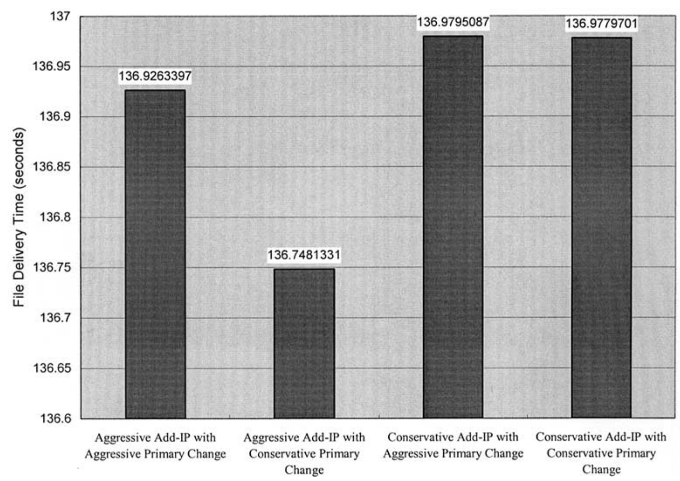

Fig. 5. mSCTP performance in the random mobility pattern.

IV. Conclusion

In this letter, we proposed a transport layer mobility scheme, mobile SCTP (mSCTP). The mSCTP can be used to provide seamless handover for mobile sessions, without any support of network routers. The mSCTP performance seems to depend on the rules for triggering to add and change IP addresses to on-going associations during the handover. From the experimental analysis, we see that the aggressive Add-IP rules and the conservative Primary-Change rules are recommended for improving the mSCTP data transport efficiency.

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