mSCTP with Bicasting for Seamless IP Handover

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Abstract*-This paper proposes the mobile SCTP (mSCTP) with bicasting for seamless IP handover. In the proposed scheme the data packets are bicast to the mobile node in the handover region. In the performance analysis, we show that the proposed scheme can reduce the service disruption time much more than the existing mSCTP handover.*

Keywords: mSCTP, bicasting, seamless handover.

1. Introduction

One of the essential issues for IP mobility is IP handover to provide a seamless handover for a mobile node that moves across the different IP subnet regions while its session is active. With this trend, the mobile Stream Control Transmission (mSCTP) has been proposed for IP handover in the transport layer [1, 2].

The mSCTP can be used to support IP handover, which provides the handover for a mobile node (MN) by adding a new IP address to the association, changing the primary address into the new address, and deleting the old IP address from the association [3, 4]. However, the mSCTP handover is subject to the rule of changing the primary address in the handover region. It is very tricky for MN to determine an optimal rule (or time) to change the primary address under a wide variety of network conditions such as wireless signal strength, available bandwidth, etc [5-8].

In this paper, we propose an extension of mSCTP with bicasting for seamless IP handover. In the proposed scheme, a correspondent node (CN) is allowed to bicast identical data to MN over both the old and new IP addresses in the handover region. The proposed scheme is simple to implement and better in the handover performance than the existing mSCTP. In particular, the proposed scheme can be used more effectively for the MN with a random or ping-pong movement pattern in the handover region.

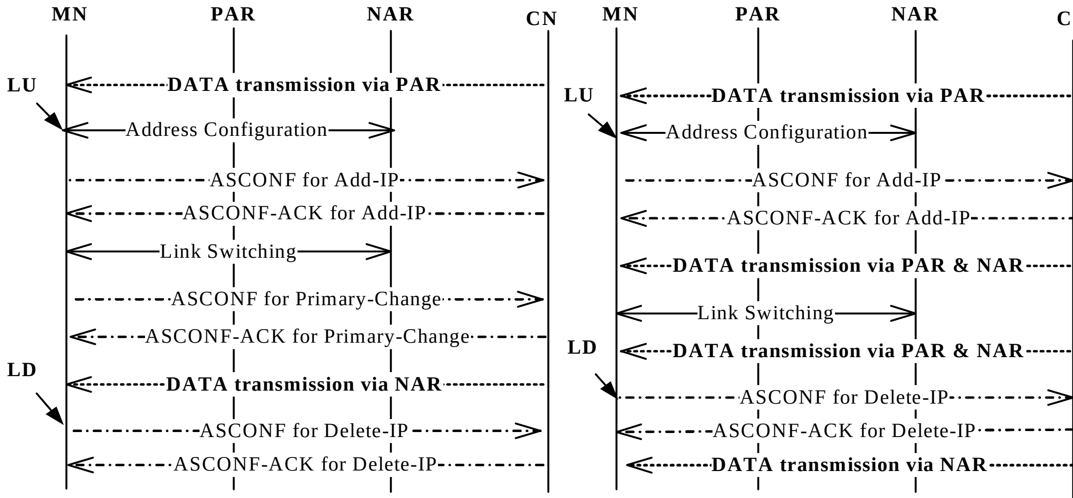
2. mSCTP Handover with Bicasting

To describe the proposed scheme, it is assumed that an MN moves from a previous access router (PAR) to a new access router (NAR). While the MN moves on, it will detect the link-up (LU) event for a new link of NAR and the link-down (LD) event for an old link of PAR. We will focus on data transmission from CN to MN in the handover region. Fig. 1 compares the proposed scheme with the existing mSCTP handover.

In the figure, when the LU event is detected, the MN begins the IP address configuration, which will include the exchange of Router Solicitation and Advertisement messages, and the DHCP procedures. After the address configuration, MN informs the newly obtained address to CN by sending the ASCONF chunk and receiving the ASCONF-ACK chunk, which is called the Add-IP operation. Then, in the proposed scheme, CN starts bicasting of the data packets to the MN over both the old and new addresses. On the other hand, in the existing mSCTP handover, CN still transmits the data packet to MN over the old address only, until the MN will change the primary address into the new address according to an appropriate primary-change rule.

On the other hand, when an LD event is detected, MN will exchange the ASCONF and ASCONF-ACK chunks with CN for the Delete-IP operation. Then, in the proposed scheme, the CN stops bicasting and transmits the data over the new address only, whereas in the existing mSCTP the CN will just delete the old address from the association.

To support the mSCTP with bicasting, the MN shall be able to ask CN for bicasting of data in the handover period. For this purpose, the ASCONF chunk needs to be extended with an additional ‘bicasting’ flag to indicate the request of bicasting, as illustrated in Fig. 2.



(a) mSCTP handover (b) mSCTP handover with bicasting

Figure 1. Comparison of mSCTP and mSCTP with bicasting

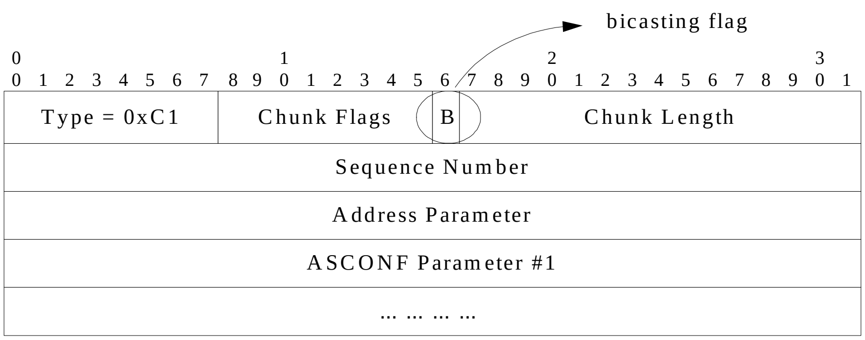


Figure 2. Bicasting flag in the ASCONF chunk

In the proposed scheme, the MN shall send the ASCONF chunks containing a bicasting flag to CN, and CN will then respond with the ASCONF-ACK chunks in the Add-IP and Delete-IP operations. In the Add-IP operation, the CN will start bicasting the data to MN, whereas it will stop the bicasting in the Delete-IP operation. If CN cannot support the mSCTP with bicasting, it shall respond with the ASCONF-ACK chunk with an error indication. In the implementations, when the MN receives the duplicate data packets by bicast, it shall be able to select only one data packet and deliver it to the upper-layer application.

3. Performance Analysis

To compare the performance of the existing and proposed schemes, we analyze the Service Disruption Time (*SDT*), which represents the amount of handover loss and latency incurred by handover. For the analytical purpose, we define the following notations:

- T_{LU} : the time at which MN detects the LU event of a new link;
- T_{LD} : the time at which MN detects the LD event of an old link;
- Address Configuration Time (*ACT*): the time duration for MN to configure a new address;
- Round Trip Time (*RTT*): the time duration taken for exchanging the ASCONF and ASCONF-ACK chunks between MN and CN for the Add-IP, Primary-Change or Delete-IP operation; and
- Link Switching Time (*LST*): the time duration taken for MN to perform the L2 handover.

The SDT of the two handover schemes will be analyzed for the two movement patterns of MN: *linear* and *random*. In the linear movement pattern, the MN moves from one subnet to the other in the one-way direction, whereas in the random movement pattern the MN will move across the two subnets irregularly, as per a certain probability model.

3.1 Linear Movement Pattern

For the existing mSCTP handover of MN, we first consider the case of $T_{LU} < T_{LD}$, in which the MN detects an LU event of the new link earlier than an LD event of the old link in the handover region. In this case, MN must perform the Add-IP operation with address configuration and change the primary address with the link switching, before the current link is down (i.e., LD event occurs). Accordingly, the SDT of MN can be calculated as:

$$SDT = T_{LU} + ACT + RTT\ (for\ Add\text{-}IP) + LST + RTT\ (for\ Primary\text{-}Change) - T_{LD} \quad (1)$$

In the equation, if $T_{LU} + ACT + RTT + LST + RTT < T_{LD}$ (i.e., all the operations are completed before T_{LD}), the SDT will be zero. In summary, the SDT for mSCTP handover can be expressed as:

$$SDT = Max\{ACT+LST+2RTT - (T_{LD} - T_{LU}), 0\} \quad (2)$$

On the other hand, if $T_{LD} \leq T_{LU}$, in which the LD event of the old link is detected before the LU event of the new link, then the MN is disconnected from the network and the SDT will be at least "*ACT + LST + 2 RTT*."

Now let us consider the SDT for the proposed mSCTP handover with bicasting. In case of $T_{LU} < T_{LD}$, the MN performs the Add-IP operation after the LU event, as done in the mSCTP handover, and then CN will bicast the data packets to MN. In this case, the Primary-Change and Link Switching operations will not affect on the SDT, since MN can receive the bicast data packets using any of the two IP addresses, until the LD event and Delete-IP operations are completed. Accordingly, the SDT for the proposed scheme can be calculated as:

$$SDT = T_{LU} + ACT + RTT\ (for\ Add\text{-}IP) - T_{LD} \quad (3)$$

Similarly as the equation (2), by noting that the SDT will be zero when $T_{LU} + ACT + RTT < T_{LD}$, we obtain

$$SDT = Max\ \{ACT + RTT - (T_{LD} - T_{LU}), 0\}. \quad (4)$$

It is clear that the SDT will be at least "*ACT + RTT*" in the case of $T_{LD} \leq T_{LU}$.

Fig. 3 shows the expected *SDT* for the existing and proposed handover schemes, as "*TLD - TLU*" varies in the handover region.

In the figure, we can see that the SDT depends on T_{LD} -T_{LU} in the handover region, which can be interpreted as the sojourn time of MN in the handover (overlapping) region between two different subnets and may depend on the cell coverage and underlying wireless link-layer technology such as soft or hard handover. In the figure, it is noted that the proposed scheme can reduce the SDT by *LST + RTT*, compared to the existing scheme, on the average.

3.2 Random Movement Pattern

Now, let us consider an MN that randomly moves across different subnet regions in the network. To analyze the SDT of MN with a random movement pattern, we employ the Markovian queuing model of M/M/1/K.

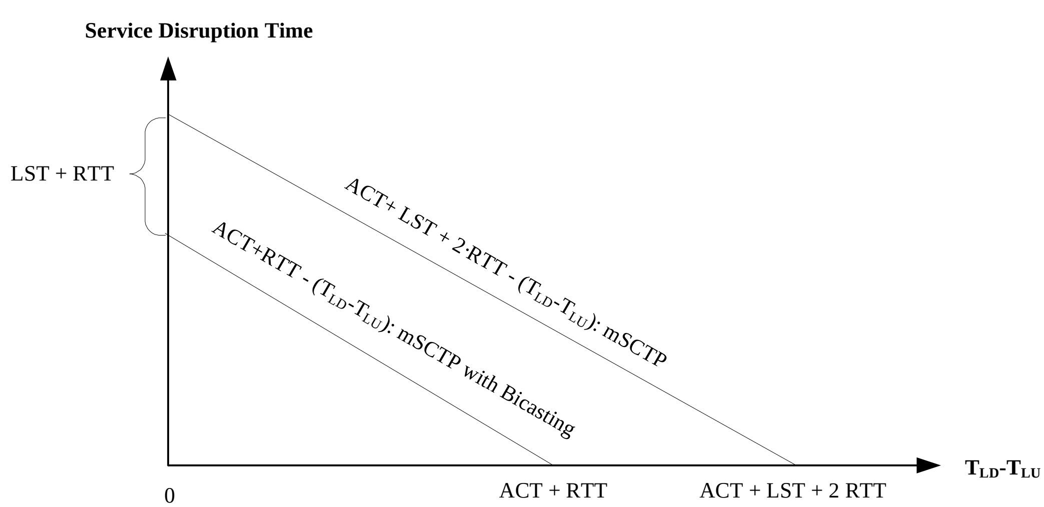


Figure 3. SDT for linear movement pattern

In the model, an MN is regarded as a single sever, and the network links available to MN are considered as the customers in the queuing system, in which the LU and LD events can be viewed as the arrival and departure events of the customers in the queuing model, respectively.

We will focus on the queuing model with the system capacity K of 2, since we consider only the two links concerned with the handover region. We assume that the LU events occur according to the Poisson process with an average rate of λ, and the service (departure) time of the LD events is exponentially distributed with an average rate of μ. In the model, the system state (S) is defined as the number of the network links attached to MN, i.e., S=0, 1, 2. For instance, S=0 indicates that the MN is disconnected from the network, S=1 when MN has only a single network link, and S=2 when it is connected to both of the two links.

From the queuing theory, we can obtain the following steady-state probability P(S):

$$P(S) = (\lambda/\mu)S \,/\{1+(\lambda/\mu)+(\lambda/\mu)^2\}, \quad \text{where } S = 0, 1, 2 \tag{5}$$

In the equation, it is noted that λ/μ represents the ratio of how much the wireless links are over-provisioned throughout the network. That is, in the network with a larger λ/μ (e.g., $\lambda/\mu > 1$), LU events will occur more frequently than LD events, and thus MN has more chances to be connected to the network.

On the contrary, in the case of $\lambda/\mu < 1$, it is more probable that MN is disconnected from the network and thus it experiences the service disruption.

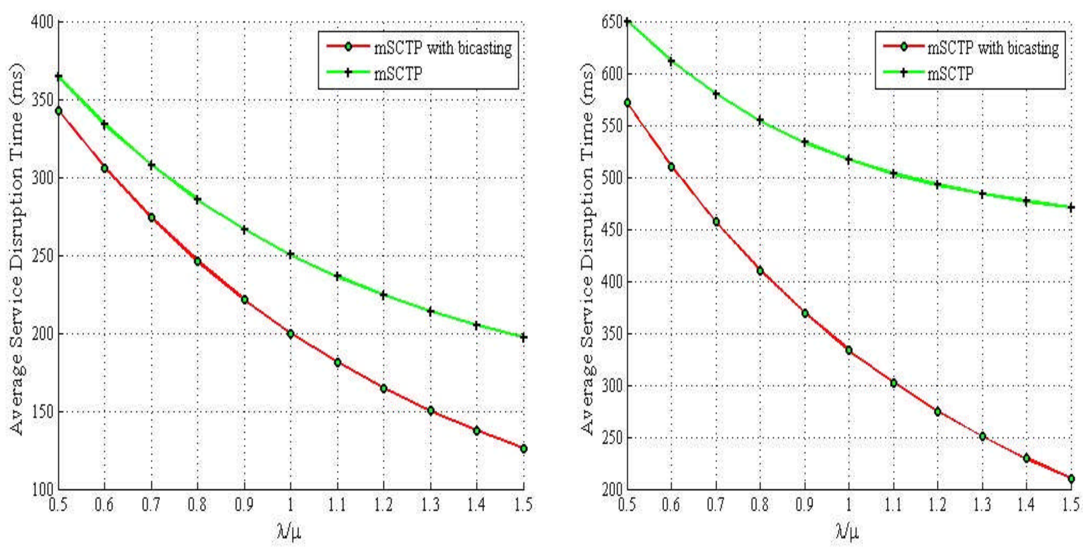
In the proposed scheme of mSCTP with bicasting, the MN will experience the service disruptions only when it stays in the disconnected network region, with the steady-state probability of P(0). In this region, the MN must obtain the new IP address and perform the ADD-IP operation to be connected to the network. Accordingly, the average SDT can be calculated as:

$$\text{Average SDT} = P(0) \times (ACT + RTT). \tag{6}$$

On the other hand, in the existing mSCTP handover, the MN is required to perform the Primary-Change operation as well as the Add-IP operation, so as to maintain the connectivity to the network. Accordingly, the corresponding SDT can be expressed as:

$$\text{Average SDT} = P(0) \times (ACT + RTT) + P(2) \times (LST + RTT). \tag{7}$$

Fig. 4 plots the average SDT times for the existing and proposed schemes using Equation (6) and (7) for two different RTTs. In the figure, ACT and LST are commonly set to 500ms and 50ms, respectively.



(a) RTT = 100ms　　(b) RTT = 500 ms

Figure 4. SDT for random movement pattern

From the figure, we can see that the average SDT decreases as λ/μ gets larger (i.e., as the network is much over-provisioned) for both the two schemes. It is noted that the proposed scheme provides a lower SDT than the existing scheme, since the proposed scheme performs the mSCTP handover with the help of bicasting, rather than using the Primary-Change operation. It is also noted that the gap of SDTs between the two schemes gets larger, as RTT becomes larger and as λ/μ increases.

4. Conclusion

This paper proposes the mSCTP handover with bicasting for seamless handover. The proposed scheme can reduce the service disruption time in the handover region much more than the existing mSCTP handover, with the help of bicasting. In particular, the proposed scheme can be used more effectively for MN with a random or ping-pong movement pattern in the handover region.

Acknowledgement

This research was supported by the MKE (The Ministry of Knowledge Economy), Korea, under the ITRC (Information Technology Research Center) support program supervised by the IITA (Institute for Information Technology Advancement) (IITA-2008-C1090-0804-0004).

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