Effect of Layer 2 Connection Setup on SIGMA performance

Shaojian Fu, Mohammed Atiquzzaman, William Ivancic

TR-OU-TNRL-05-103
January 2005

Telecommunication & Network Research Lab

School of Computer Science

THE UNIVERSITY OF OKLAHOMA

200 Felgar Street, Room 159, Norman, Oklahoma 73019-6151
(405)-325-4042, atiq@ou.edu, www.cs.ou.edu/~atiq

Effect of Layer 2 Connection Setup on SIGMA performance

Shaojian Fu
Mohammed Atiquzzaman
School of Computer Science
University of Oklahoma,
Norman, OK 73019-6151.

William Ivancic
Satellite Networks & Architectures Branch
NASA Glenn Research Center
21000 Brookpark Rd. MS 54-8,
Cleveland, OH 44135.

***Abstract*— In our earlier study, we proposed SIGMA, a Seamless IP diversity based Generalized Mobility Architecture. SIGMA utilizes multihoming to achieve a seamless handover of a mobile host, and is designed to solve many of the drawbacks of Mobile IP. In this paper, we evaluate the impact of Layer 2 connection setup on the performance of SIGMA. Various aspects of Layer 2 connection setup are considered such as Layer 2 setup latency, layer 2 beacon period, and mobile host moving speed. Criteria for performance evaluation include handover latency, packet loss, throughput. Our results show that SIGMAhandover latency is insensitive to Layer 2 setup latency and beacon periods. Moreover, SIGMA can achieve a seamless handover if MH's moving speed is not too high.**

I. INTRODUCTION

Mobile IP (MIP) [1] is the standard proposed by IETF to handle mobility of Internet hosts for mobile data communication. Several drawbacks exist when using MIP in a mobile computing environment, the most important issues of MIP identified to date are high handover latency, and high packet loss rate [2]. Even with various recent proposed enhancements [2], [**?**], [**?**], Mobile IP still can not completely remove the latency associated handover, and the resulting packet loss rate is still high [3].

As the percentage of real-time traffic over wireless networks keeps growing, the deficiencies of the network layer based Mobile IP in terms of high latency and packet loss becomes more obvious. A transport layer mobility solution would be a natural candidate for an alternative approach, since most of the applications in the Internet are end-to-end. A number of transport layer mobility protocols have been proposed in the context of TCP: MSOCKS [4] and connection migration solution [5]. These protocols tried to implement mobility as an end-to-end service without the requirement on the network layer infrastructures; they are not aimed at reducing the high latency and packet loss resulted from handovers. The handover latency for these schemes is in the scale of seconds.

We designed a new scheme for supporting low latency, low packet loss mobility called Transport Layer Seamless Handover (SIGMA) [6]. It can also cooperate with normal IPv4 or IPv6 infrastructure without the support of Mobile IP. Similar in principle to a number of recent transport layer handover schemes [7], [8], [9], the basic idea of SIGMA is to exploit multihoming to keep the old path alive during the process of setting up the new path to achieve a seamless handover. However, a practical obstacle to realizing this principle is the existence of layer 2 handover latency, which is due to the physical and/or link layer limitations of the state-of-the-art mobile systems such as IEEE 802.11, GPRS, UMTS, etc. For example, in IEEE 802.11 WLAN, when a mobile host changes its point of attachment to the network, it need to perform a layer 2 (data link layer) handover to cutoff the association with the old access point and re-associate with a new one, which could take up to 600-700ms [10]. The SIGMA signaling messages cannot flow until the completion of the layer 2 handover, and this delay may break the parallelism that we hope to achieve with multihomed transport layer connection.

Therefore, SIGMA's handover performance is affected by the layer 2 handover to some extent, even though SIGMA does not require any change on the layer 2 or layer 3 implementation. The *objective* of this paper is to look into the effect of layer 2 handover on the SIGMA performance. Similar to paper [6], we illustrate SIGMA using SCTP since multihoming is a built-in feature of SCTP.

The *contributions* of our paper can be outlined as follows:

The research reported in this paper was funded by NASA Grant NAG3-2922.

- Illustrate the interaction between layer 2 and layer 4 handover procedure in SIGMA.
- Evaluate the performance of SIGMA under various aspects of layer 2 handover. The authors are not aware of any *previous studies in the layer 2 handover effect on transport layer mobility solutions*.

The rest of this paper is structured as follows: Sec. II outlines the handover signalling procedures, timing diagram of SIGMA. The general impact of layer 2 handover latency on SIGMA is discussed in Sec. III. Then we evaluate the effect of L2 handover on the performance of SIGMA by *ns*-2 simulation. Simulation topology and parameters are described in Secs. IV-A and IV-B, respectively. Sec. V illustrate the impact of layer 2 handover latency on SIGMA handover performance through packet trace and congestion window trace. The results of SIGMA performance under various layer 2 handover parameters are shown in Sec. VI. Finally, concluding remarks are presented in Sec. VII.

II. Architecture of SIGMA

A typical mobile handover in SIGMA using SCTP as an illustration is shown in Fig. 1, where the Mobile Host (MH) is multi-homed node connected through two wireless access networks. Correspondent node (CN) is a single-homed node sending traffic to MH, which corresponds to the services like file download or web browse by the mobile users.

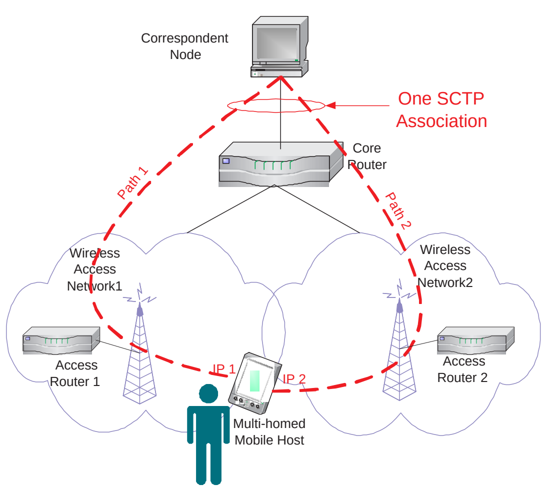

Fig. 1. An SCTP association with multi-homed mobile host.

A. Handover process

The handover process of SIGMA can be described by the following five steps.

STEP 1: Obtain new IP address

Refer to Fig. 1 as an example, the handover preparation procedure begins when MH moves into the overlapping radio coverage area of two adjacent subnets. Once the MH receives the router advertisement from the new access router (AR2), it should begin to obtain a new IP address (IP2 in Fig. 1). This can be accomplished through several methods: DHCP, DHCPv6, or IPv6 stateless address autoconfiguration (SAA) [11].

STEP 2: Add IP addresses into the association

After the MH obtained the IP address IP2 by STEP 1, MH should notify CN about the availability of the new IP address through SCTP Address Dynamic Reconfiguration option [12]. This option defines two new chunk types (ASCONF and ASCONF-ACK) and several parameter types (Add IP Address, Delete IP address, and Set Primary Address etc.).

STEP 3: Redirect data packets to new IP address

When MH moves further into the coverage area of wireless access network2, CN can redirect data traffic to new IP address IP2 to increase the possibility that data can be delivered successfully to the MH. This task can be accomplished by sending an ASCONF from MH to CN, through which CN set its primary destination address to MH's IP2. At the same time, MH need to modify its local routing table to make sure the future outgoing packets to CN using new path through AR2.

STEP 4: Update location manager (LM)

SIGMA supports location management by employing a location manager which maintains a database recording the correspondence between MH's identity and MH's current primary IP address. MH can use any unique information as its identity such as home address like MIP, or domain name, or a public key defined in Public Key Infrastructure (PKI).

Following our example, once MH decides to handover, it should update the LM's relevant entry with new IP address IP2. The purpose of this procedure is to ensure that after MH moves from wireless access network1 into network2, further association setup requests can be routed to MH's new IP address IP2. This update has no impact on the existing active associations.

We can observe an important difference between SIGMA and MIP: the location management and data traffic forwarding functions are coupled together in MIP, while in SIGMA they are decoupled to speedup handover and make the deployment more flexible.

STEP 5: Delete or deactivate obsolete IP address

When MH moves out of the coverage of wireless access network1, no *new* or *retransmitted* data should be directed to address IP1. In SIGMA, MH notifies CN that IP1 is out of service for data transmission by sending an ASCONF chunk to CN to delete IP1 from CN's available destination IP list.

A less aggressive way to prevent CN from sending data to IP1 is MH advertising a zero receiver window (corresponding to IP1) to CN. This will give CN an impression that the interface (on which IP1 is bound) buffer is full and can not receive data any more. By deactivating, instead of deleting, the IP address, SIGMA can adapt more gracefully to MH's zigzag movement patterns and reuse the previous obtained IP address (IP1) as long as the IP1's lifetime is not expired. This will reduce the latency and signalling traffic caused by obtaining a new IP address.

B. *Timing diagram of* SIGMA

The numbers before the events correspond to the step numbers in Sec. II-A. Fig. 2 summarizes the signalling sequences involved in SIGMA. Here we assume IPv6 SAA is used for MH to get new IP address. It should be noted that before the old IP is deleted at CN, it can always receive data packets (not shown in the figure) in parallel with the exchange of signalling packets.

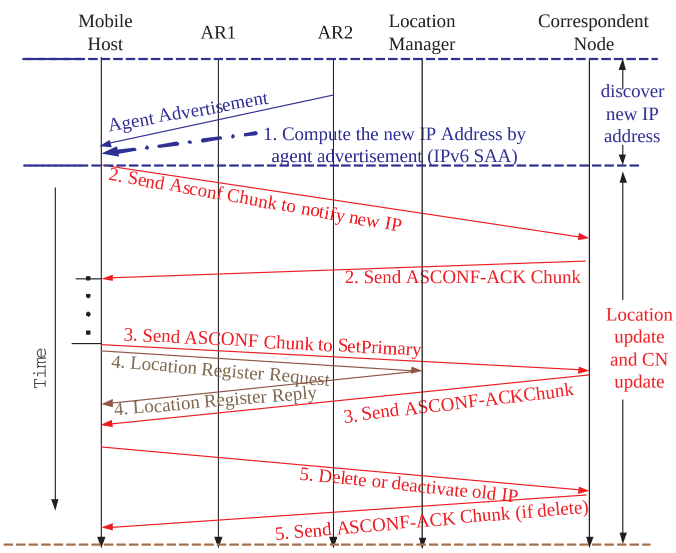

Fig. 2. Timing diagram of SIGMA

III. General impact of Layer 2 handover on SIGMA

A. *Layer 2 handover concept*

In the state of the art mobile system technologies, when a mobile host changes its point of attachment to the network, it need to perform a layer 2 (data link layer) handover to cutoff the association with the old access point and re-associate with a new one. As an example, in IEEE802.11 WLAN infrastructure mode, this layer 2 handover will require several steps: detection, probe, and authentication and reassociation with new AP. These procedures can take up to 600-700ms [10] to set up the new layer 2 connection, after which higher layer protocols can proceed with their signaling procedure.

B. *Impact of layer 2 handover on* SIGMA

In SIGMA, the layer 2 handover will postpone the time that MH can start STEP1 (obtain new IP address), since only after layer 2 handover finishes, MH can receive the router advertisement from the new AR. Therefore the STEP2 is also postponed because this step is in synchronous with the STEP1. However, the time of starting STEP3 and STEP4 may or may not be affected by the layer 2 handover latency. Consider a linear movement from AR1 to AR2 as an example, ideally (without any layer 2 handover latency) the STEP3 and STEP4 of SIGMA handover should start at (say time t) the point of the overlapping region that gives MH enough time to finish STEP3 and STEP4 before it moves out of the coverage of AR1. When layer 2 handover latency come into play, depending on the MH's moving speed, overlapping region size, round trip time from MH to CN (for ADDIP chunks to come back), the time (say time t') that STEP2 finishes could fall before or behind the time t. If $t' \leq t$, the layer 2 handover has virtually no impact on SIGMA handover since the new data path through AR2 is available before MH moves into coverage of AR2, and there is no loss happened due to SIGMA handover. However, if $t' > t$, the layer 2 handover push the latest starting point of STEP3 and STEP4 from t to t', which will cause these two steps cannot be finished before MH moves out of AR1 coverage, and some packet losses will happen.

IV. Simulation topology and parameters

In this section, we describe the simulation topology and parameters that have been used to compare the performance of SIGMA and MIP. We have used *ns-2* simulator that supports SCTP as the transport protocol. We implemented SIGMA protocol for *ns-2* to support the simulation comparison.

A. *Simulation topology*

The network topology used in our simulations for SIGMA is shown in Fig. 3. This topology has been used extensively in earlier MIP performance studies [**?**], [13]. In the figure, AR1 and AR2 stand for two access routers. MH initially has an IP address of 2.0.1 when it is associated with AR1. After moving into the overlapping region,

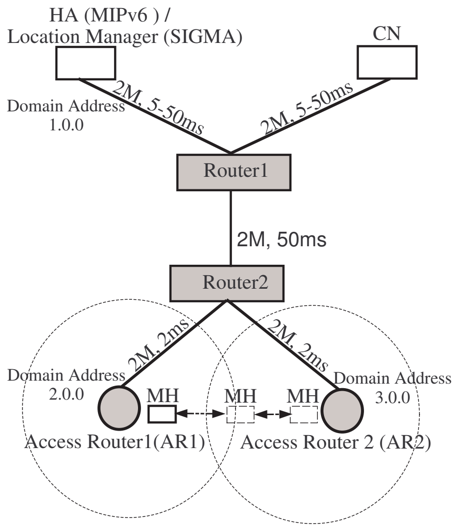

Fig. 3. Simulation topology.

MH will get new IP address 3.0.1 from AR2, which will make it have two IP (2.0.1 and 3.0.1) available at the same time. Once MH moves out of the coverage of AR1, the old IP address (2.0.1) is deleted and only 3.0.1 is available. The link characteristics, namely the bandwidth (Megabits/s) and propagation delay (milliseconds), are shown on the links.

B. Simulation parameters

we have used the following parameters in our simulations:

- A pair of FTP source and sink agents are attached to the CN and MH, respectively, to transfer bulk data from CN to MH. To stabilize the result, each simulation run lasts for 500 seconds of MH's linear back and forth movement between AR1 and AR2.
- Each base station has a radio coverage area of approximately 40 meters in radius. The overlapping region between two ARs is 10 meters.
- To make a fair comparison, we have used standard SCTP protocol (without mobility related modifications) as the transport layer protocol for MIPv6 enhancements. This is to ensure that all the handover schemes use the same connection setup and congestion control control mechanisms, and that the results are only affected by the different handover schemes.

V. PACKET TRACE OF SIGMA

In this section, we will show simulation packet traces and congestion window traces of SIGMA to illustrate the impact of layer 2 handover latency on SIGMAhandover performance. These trace results can be classified into three categories: (1) no layer 2 handover latency, (2) layer 2 handover latency does not cause packet loss in SIGMA handover, (3) layer 2 handover latency introduce some packet losses in SIGMA handover. In all categories, the IP address resolution latency is set to 500ms.

A. No layer 2 handover latency

Fig. 4 shows the packet trace observed at the CN during one typical handover for SIGMA with data being sent from CN to MH. Layer 2 handover has no latency, i.e. it finishes immediately. The segment sequence numbers are shown as MOD 100. From Fig. 4 we can observe that SCTP data segments are sent to MH's old IP address (2.0.1) until time 8.140 sec (point t_1), then the new IP address (3.0.1) almost immediately (point t_2), and all these packets are successfully delivered to MH. Since the change of routing table at MH takes at the same time as the sending of SetPrimary chunk to CN at STEP3 in II-A, the ACKs sent to CN after time 8.134 sec (the time handover decision is made) use the new path through AR2, which is not the same as the path receiving the data packets before time 8.140 sec. Also note that at t_2 a slow start begins at transport address 3.0.1. The initial congestion window ($cwnd$) is three instead of two specified in RFC2960 because CN has received an ACK from the new path and $cwnd$ is increased by one segment size. The next window of data is sent to 3.0.1 at time 8.40 sec using $cwnd$ of 6 according to slow start algorithm.

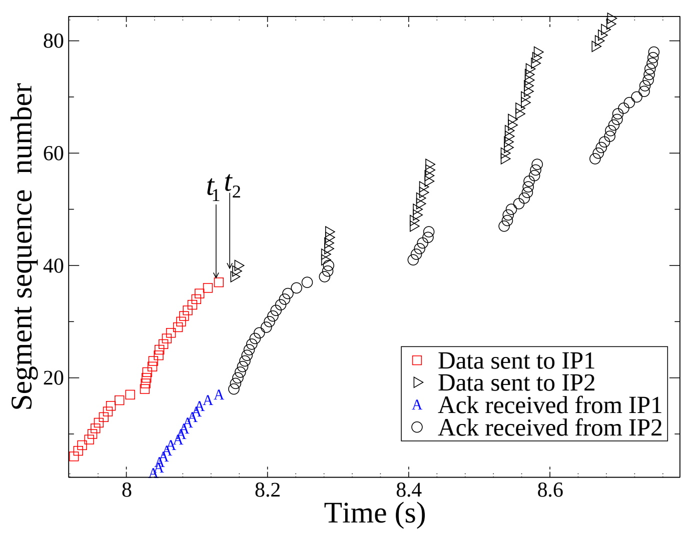

Fig. 4. Segment sequence of SIGMA during one handover with no L2 handover latency.

Fig. 5 shows the CN's congestion window evolution corresponding to the no layer 2 latency case within 100 secs. The time instants labelled with odd subscripts (t_1,

t_3, t_5, and t_7) stand for a handover happens from AP1 to AP2, while the ones labelled with even subscripts (t_2, t_4, t_6, and t_8) stand for a handover happens from AP2 to AP1. This figure shows that SIGMA can achieve seamless handover as evidenced by the fact that the $cwnd$ for new path picks up before the $cwnd$ for old path drops (which is due to no data is directed to the old path after new path becomes the primary path). Moreover the $cwnd$ for new path is increased according to slow start algorithm to probe the new network gradually after the handover, which means SIGMA is network friendly.

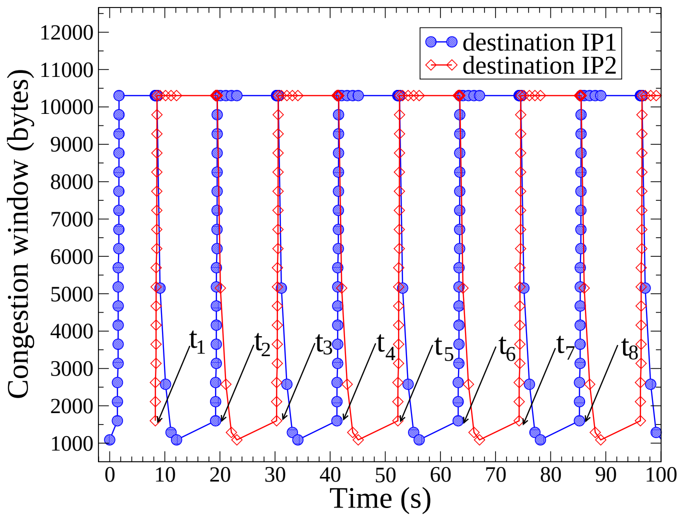

Fig. 5. CN's congestion window during one handover with no L2 handover latency.

B. Low layer 2 handover latency

Fig. 6 shows the packet trace observed at the CN during one typical handover for SIGMA with layer 2 handover latency of 200ms. From Fig. 6 we can observe that SCTP data segments are sent to MH's old IP address (2.0.1) until time 8.16 sec (point t_1), then the new IP address (3.0.1) almost immediately (point t_2), and all these packets are successfully delivered to MH. Therefore, SIGMA still experienced a seamless handover because it can prepare the new path in parallel with data forwarding over the old path. We found that in this kind of scenario *the only impact of layer 2 handover is to push the time instant of transport layer handover by 20ms* (8.14 sec vs. 8.16 sec). This is the basic reason that explains why SIGMA can achieve a low handover latency, low packet loss rate and high throughput as shown in [6].

Fig. 7 shows the CN's congestion window evolution corresponding to the case of 200ms layer 2 handover latency within 100 secs. This figure shows that SIGMA

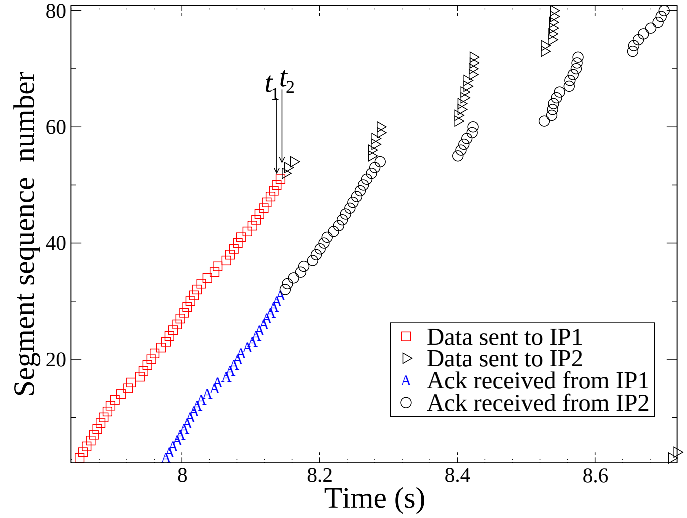

Fig. 6. Segment sequence of SIGMA during one handover with no L2 handover latency.

can still achieve seamless handover with this layer 2 latency. The $cwnd$ for path through 2.0.1 and path through 3.0.1 pick up and drop alternatively in a smooth manner.

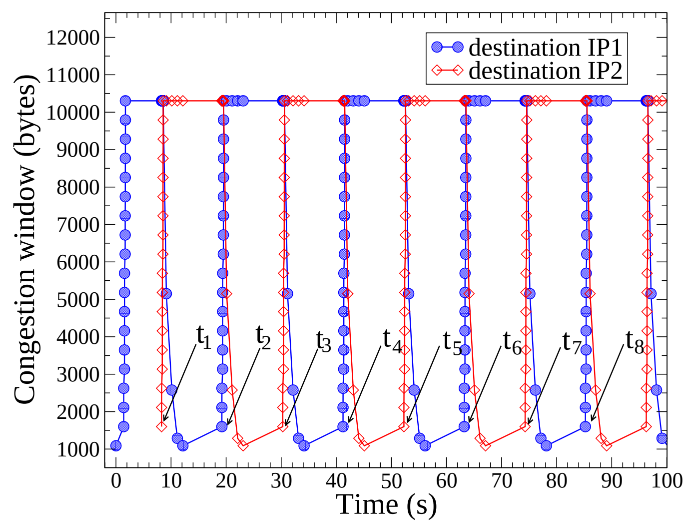

Fig. 7. CN's congestion window during one handover with low L2 handover latency.

C. High layer 2 handover latency

Fig. 8 shows the packet trace observed at the CN during one typical handover for SIGMA with layer 2 handover latency of 500ms. From Fig. 8 we can observe that the SCTP segments sent to address 2.0.1 start at t_1 until the end of the window are all lost. The reason for this is that layer 2 handover postpone the preparation of new path,while the old path will be unavailable after time 9 sec. The RTO value for the old path at this time is 1.0 sec. Therefore, at time t_2 (around time 10.0 sec.), the first lost segment is retransmitted to the new path, which is delivered successfully. However, the SIGMA handover still have not finished by this time, and the routing table from MH to CN still requires the ACK go through the old path, which is lost again. This will make the RTO of the new path doubled to 2.0 sec. The next retransmission that happens at the old path. This time the initial RTO value of new path will be used: 3.0 sec. as specified by RFC2960, which results in the retransmission taking place at time 13.0 sec (10.0+ RTO value 3.0 at new path). This retransmitted packet is also lost since the old path is not available at that time. Only after time 15 sec. (13.0+RTO value 2.0 at old path) the third retransmission make the association back to the normal transmission.

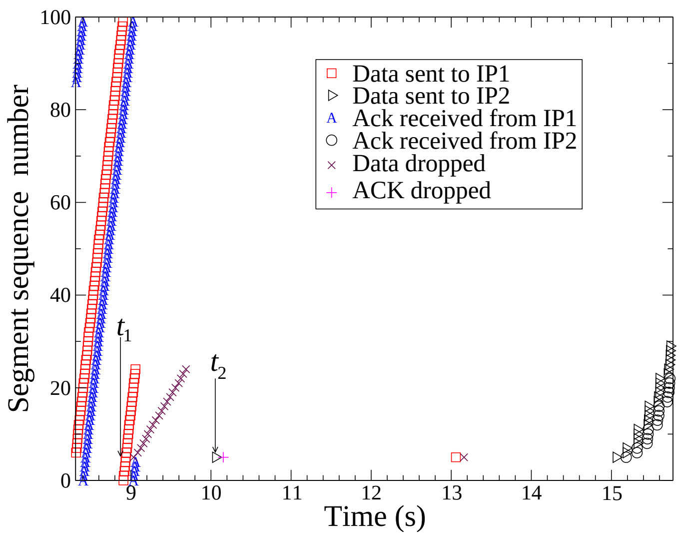

Fig. 8. Segment sequence of SIGMA during one handover with high L2 handover latency.

Fig. 9 shows the CN's congestion window evolution corresponding to the case of 500ms layer 2 handover latency within 100 secs. This figure shows that SIGMA can not achieve seamless handover with this layer 2 latency. The *cwnd* for path through 2.0.1 and path through 3.0.1 cannot alternate smoothly, and there is virtually no packets are sent when *cwnd* for both pathes are low.

VI. Comparison Results Showing Effect of Various Layer 2 Handover Parameters

In this section, we present comparison results showing the effect of various layer 2 handover parameters on SIGMA in terms of handover latency, throughput, and packet loss rate.

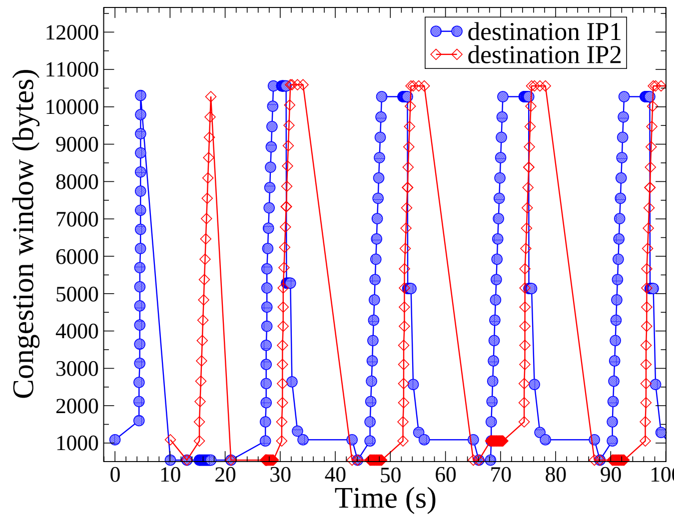

Fig. 9. CN's congestion window during one handover with high L2 handover latency.

A. Handover latency

We define the *handover latency* as the time interval between the last data segment received through the old path and the first data segment received through the new path from CN to MH. In this section, we will examine the impact of different parameters on the overall handover latency of SIGMA. These parameters include L2 handover latency, IP address resolution latency, moving speed, and the layer 2 beacon period.

1) Impact of L2 handover latency: First we look at the overall handover latency of SIGMA when the L2 handover latency range from 100 to 600ms, and IP address resolution latency ranges from 300 to 600ms. The values of L2 handover latency corresponds to the empirical values in IEEE 802.11 networks [10]. The moving speed is fixed at 5m/s. It can be seen from Fig. 10 that the overall handover latency of SIGMA is very low (in the range of 5-10ms) when the combined latency of layer 2 handover and IP address resolution is less than 900ms. This is because when the MH is using the old path to do communication with CN, it can perform the L2 handover and address resolution on the other interface in parallel (as shown in packet trace in Sec. V-A and V-B), thus the impact of these latencies can be noticeably reduced compared to MIP. When the combined latency is larger than 900ms, this parallelism is broken since the MH does not have enough time to finish all the signaling required in SIGMA. Some packets sent to the outdated AR are lost and CN is forced to backoff by SCTP's congestion control algorithms. The packet trace in Sec. V-C shows the example where high layer 2 latency causes packet losses and high SIGMA handover latency.

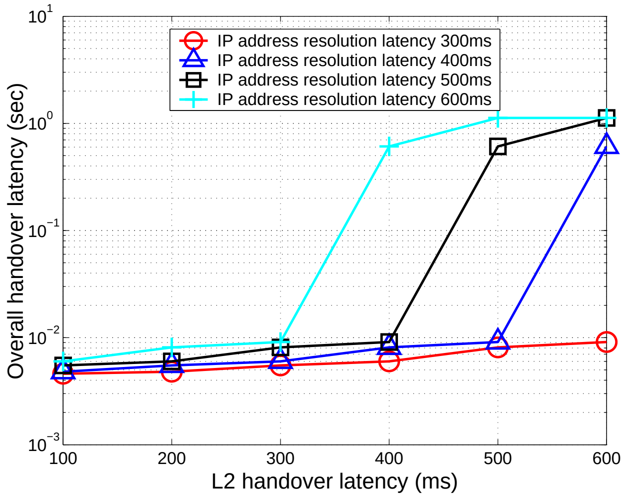

Fig. 10. Impact of L2 handover latency and address resolution latency

2) *Impact of moving speed and layer 2 beacon period:* Next we vary the movement speed of MH from 2.5m/s up to 20m/s, vary the layer 2 beacon period from 20ms to 80ms, and fix both of the L2 handover latency, address resolution latency to 100ms. As shown in Fig.11, when MH's moving speed is less than 15m/s, the impact of moving speed is not obvious. When MH moves faster, SIGMA will experience a higher handover latency due to MH having insufficient time to prepare for the handover. Therefore, there is a higher possibility that the packets are forwarded to the outdated path and get lost, and the time instant that MH can receive the packets from new path will be postponed and the handover latency increases accordingly.

Comparing the curves of different layer 2 beacon period in Fig.11, we can see a layer2 beacon period of 20ms generates the highest SIGMA handover latency at low moving speeds (under 15m/s). This is because too low a beacon period (e.g. 20ms) produces a high volume of beacons, which will contend for the limited wireless bandwidth with data and SIGMA signaling traffic. The packet loss rate for the signaling packets thus increase and it may require additional retransmission time to deliver them successfully. The resulted handover latency will therefore be increased. However, at higher speed (more than 15m/s), the low layer 2 beacon period can help the MH to detect the new AP and begin layer 2 handover earlier, thus reduce the possibility that packets are forwarded to outdated path. The resulted handover latency decreases accordingly.

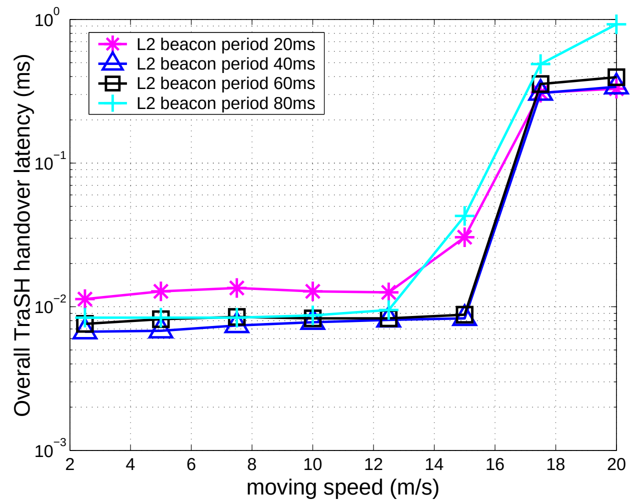

Fig. 11. Impact of moving speed and layer 2 beacons

B. Throughput and packet loss rate

We define the *throughput* as the total useful bits that can be delivered to MH's upper layer application divided by the simulation time, which gives us an estimate of average transmission speed that can be achieved by the SCTP association. The *packet loss rate* is defined as the number of lost packets due to handover divided by the total number of packets sent by CN. In this section, we will examine the impact of different parameters on the throughput and packet loss rate of SIGMA. These parameters are the same ones as we have seen in Sec. VI-A.

1) *Impact of L2 handover latency and address resolution latency:* It can be seen from Fig. 12 that the packet loss rate caused by SIGMA handover is zero when the combined latency of layer 2 handover and IP address resolution is less than 900ms. Also Fig. 13 shows that the throughput of SIGMA is much higher in these cases, because the packet losses will trigger congestion control and force the sender to reduce the sending rate. High packet loss rate happens when the combined latency larger than 900ms. This is because the time-consuming L2 handover and new IP address resolution will disable the MH to finish SIGMA signaling in time before it moves out of the overlapping region, and some packets are sent to the outdated location and get lost.

2) *Impact of moving speed:* When MH moves faster than 15m/s, SIGMA will experience a higher packet loss rate (Fig. 14) and decreased throughput (Fig. 15) compared with low moving speed. This is because that the possibility of packets being forwarded to outdated path will increase with an increase in the speed. Those packets are dropped by the AR1/AR2, either because

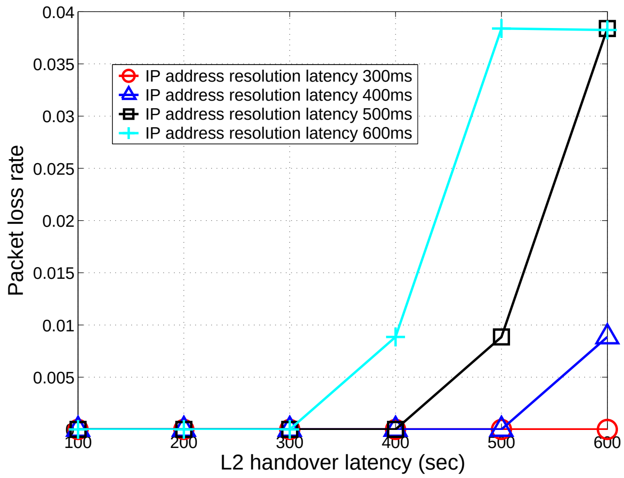

Fig. 12. Impact of L2 handover latency and address resolution latency on packet loss rate

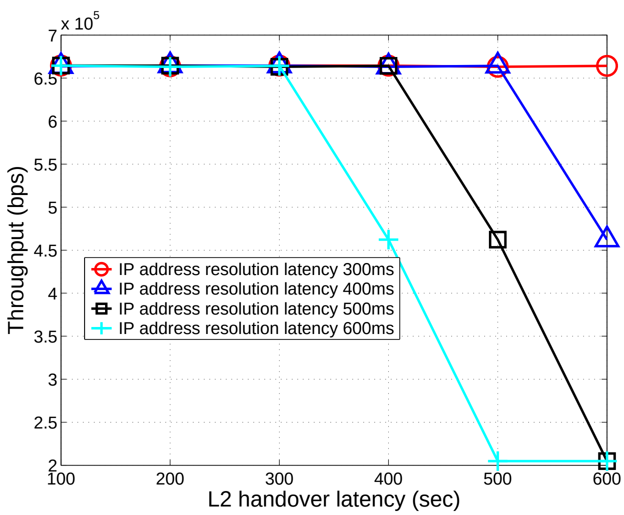

Fig. 13. Impact of L2 handover latency and address resolution latency on throughput

they are not aware of MH's current location or the buffer space is full.

As shown in VI-A.2, too low a beacon period (20ms) produces a high volume of beacons, which will contend for the limited wireless bandwidth with data and SIGMA signaling traffic, thus increase the packet loss rate. We can also notice that reducing the layer 2 beacon period can somewhat offsets the impact of high speed by detect the new AP and begin layer 2 handover earlier. Therefore there will be a smaller probability that the packets are sent to an outdated location and get dropped by the AR.

VII. Conclusions

This paper evaluates the impact of layer 2 handover on SIGMA performance. Different performance measures,

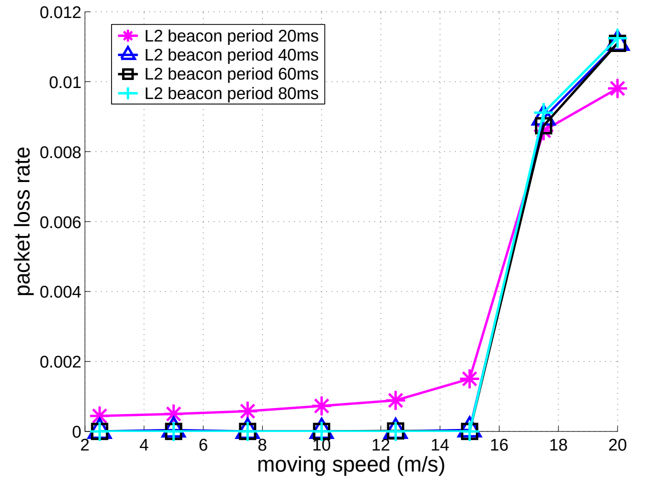

Fig. 14. Impact of moving speed and beacon period on packet loss rate

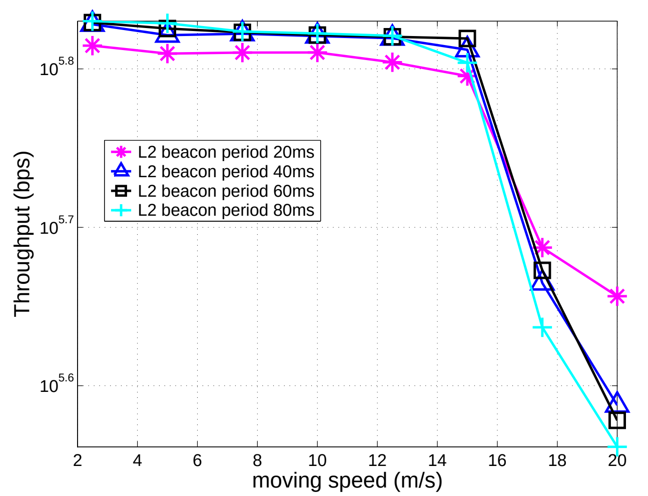

Fig. 15. Impact of moving speed and beacon period on throughput

including handover latency, packet loss and throughput, have been compared. Our results indicate that for typical network configuration and parameters, SIGMA is not sensitive to layer 2 handover latency and beacon periods. SIGMA has also been shown to be able to handle relatively high speed movement.

References

[1] C.E. Perkins, "Mobile Networking Through Mobile IP," *IEEE Internet Computing*, vol. 2, no. 1, pp. 58–69, January/February 1998.

[2] K.E. Malki (editor), "Low latency handoffs in Mobile IPv4." IETF DRAFT, draft-ietf-mobileip-lowlatency-handoffs-v4-07.txt, October 2003.

[3] R. Hsieh and A. Seneviratne, "A comparison of mechanisms for improving Mobile IP handoff latency for end-to-end TCP," *ACM MobiCom*, San Diego, USA, pp. 29–41, September 2003.

[4] D. A. Maltz and P. Bhagwat, “MSOCKS: An architecture for transport layer mobility,” *INFOCOM*, San Francisco, USA, pp. 1037–1045, March 1998.

[5] A. C. Snoeren and H. Balakrishnan, “An end-to-end approach to host mobility,” *ACM MobiCom*, Boston, MA, pp. 155–166, August 2000.

[6] S. Fu, M. Atiquzzaman, J.S. Jones, Y. Lee, S. Lu, and L. Ma, “SIGMA: Seamless IP diversity based Generalized Mobility Architecture,” tech. rep., Computer Science, University of Oklahoma, www.cs.ou.edu/˜atiq, November 2003. Accepted for publication by ICC, Seoul, Korea, May 2005.

[7] S. J. Koh, M. J. Lee, M. L. Ma, and M. Tuexen, *Mobile SCTP for Transport Layer Mobility*. draft-sjkoh-sctp-mobility-03.txt, February 2004.

[8] W. Xing, H. Karl, and A. Wolisz, “M-SCTP: Design and prototypical implementation of an end-to-end mobility concept,” *5th Intl. Workshop on the Internet Challenge: Technology and Applications*, Berlin, Germany, October 2002.

[9] L. Li, “PKI based end-to-end mobility using SCTP,” *MobiCom 2002*, Atlanta, Georgia, USA, September 2002.

[10] A. Mishra, M. Shin, and W. Arbaugh, “An empirical analysis of the IEEE 802.11 MAC layer handoff process,” *ACM SIGCOMM Computer Communication Review*, vol. 33, no. 2, pp. 93–102, April 2003.

[11] S. Thomson and T. Narten, “IPv6 stateless address autoconfiguration.” IETF RFC 2462, December 1998.

[12] R. Stewart, M. Ramalho, and Q. Xie et. al., “Stream control transmission protocol (SCTP) dynamic address reconfiguration.” IETF DRAFT, draft-ietf-tsvwg-addip-sctp-09.txt, June 2004.

[13] Robert Hsieh, Zhe Guang Zhou, and Aruna Seneviratne, “S-MIP: A seamless handoff architecture for Mobile IP,” *IEEE INFOCOM*, San Francisco, CA, pp. 1774–1784, April 2003.