Effect of Layer 2 Connection Setup on Performance of SIGMA

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I. INTRODUCTION

Mobile IP (MIP) [1] has been designed to handle mobility of Internet hosts. MIP is known to suffer from high handover latency and high packet losses. Even the various recent proposed enhancements [2], [3] can not completely remove the handover latency, still resulting in a high packet loss rate [4].

To achieve seamless handoff, we designed a new mobility management scheme called Seamless IP diversity based Generalized Mobility Architecture (SIGMA) [5] to reduce handover latency and packet loss. The basic idea of SIGMA is to exploit IP diversity offered by multiple paths between Mobile Host (MH) and its Correspondent Node (CN); to achieve a seamless handover, the old path is kept alive during the process of setting up a new path. However, the issue of Layer 2 setup latency due to physical and/or link layer limitations of standards, such as IEEE 802.11, GPRS, UMTS, etc., needs to be investigated to realize SIGMA. The Layer 2 connection setup time consists of the time between MH's entry into the coverage and the establishment of the Layer 2 connection, which could take up to 600-700ms [6]. The signaling messages of SIGMA through the new access point cannot flow until the completion of the Layer 2 setup. The question to be answered in this paper is: Does Layer 2 connection setup have any effect on the parallelism we expect to achieve through IP diversity? The *objective* of this paper is to investigate the effect of Layer 2 connection setup on the performance of SIGMA. The *contributions* of our paper can be outlined as follows:

- Illustrate the interaction between Layer 2 connection setup and transport layer handover procedure in SIGMA.
- Evaluate the performance of SIGMA for various Layer 2 parameters. The authors are not aware of any *previous studies on the impact of Layer 2 setup latency on transport layer mobility solutions*.

We evaluate the effect of Layer 2 connection setup on the performance of SIGMA by *ns-2* simulation. Simulation setup and results are described in Secs. II and III, respectively. Finally, concluding remarks are presented in Sec. IV.

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II. SIMULATION TOPOLOGY AND PARAMETERS

The network topology shown in Fig. 1 has been used to study the effect of Layer 2 connection setup in SIGMA. IEEE 802.11 is used as the MAC protocol. AR1 and AR2 are two access routers corresponding to the two subnets involved in the handoff. The Stream Control Transmission Protocol (SCTP) [7], with built-in multihoming capabilities, has been used in the simulation to support IP diversity. The link characteristics, namely the bandwidth (megabits/s) and propagation delay (milliseconds), are shown on the links. MH initially has an IP address of IP1 when it is associated with AR1. After moving into the overlapping region, MH acquires a new IP address (IP2) from AR2, while still retaining IP1. Once MH moves out of the coverage of AR1, IP1 is deleted and only IP2 is available.

Fig. 1. Simulation topology.

III. SIMULATION RESULTS

In this section, we illustrate and measure the impact of Layer 2 connection setup on the performance of SIGMA. The impact is illustrated by two types of results: (a) impact of Layer 2 setup latency, and (b) impact of MH's speed and Layer 2 beacon periods. Although we have measured the overall handover latency, end to end throughput, and packet loss rate as performance criteria, due to the space limitation, we only show part of the results in this abstract.

A. Impact of Layer 2 setup latency

Fig. 2 shows packet trace observed at the CN during a typical SIGMA handover with data being sent from CN to MH with no Layer 2 setup latency. The segment sequence numbers are shown as MOD 100. We can observe that data segments are sent to IP1 until time 8.140 sec (point t_1), and then to IP2 almost immediately (point t_2), with all these packets being successfully delivered to MH.

Fig. 2. Segment sequence of SIGMA during one handover with no Layer 2 setup latency.

Fig. 3 shows the packet trace observed at the CN during a typical SIGMA handover with Layer 2 setup latency of 200ms. We can observe that data segments are sent to IP1 until time 8.16 sec (point t_1), and then to IP2 almost immediately (point t_2), with all the packets being successfully delivered to MH. Therefore, SIGMA experienced a seamless handover even with Layer 2 setup latency; this is because the new path is setup in parallel to data forwarding over the old path. *The only impact of Layer 2 setup is to push the time instant of SIGMA handover by 20ms* (8.14 sec vs. 8.16 sec). This explains the basics of how SIGMA achieves a low handover latency, low packet loss rate and high throughput (given in detail in [5]).

Fig. 3. Segment sequence of SIGMA during one handover Layer 2 setup latency of 200ms.

B. Impact of speed and Layer 2 beacon period on packet loss

To measure the performance of SIGMA, we varied the speed of MH from 2.5m/s to 20m/s, the Layer 2 beacon period from 20ms to 80ms, and fixed the Layer 2 setup latency to 100ms.

Fig. 4. Impact of moving speed and beacon period on packet loss rate

As shown in Fig. 4, the impact of MH's speed is not obvious when the speed is less than 15m/s. When MH moves faster, SIGMA experiences a higher packet loss rate. This is because of increase in the possibility of packets being forwarded to an outdated path as the speed increases. Those packets are dropped by AR1/AR2, either because they are not aware of MH's current location or the buffer space is full.

Comparing the packet loss rate for different Layer 2 beacon periods in Fig. 4, it is observed that a very small beacon period (20ms) produces a large number of beacons, which contend with data and SIGMA signaling traffic for the limited wireless bandwidth, thereby increasing the packet loss rate. We also notice that reducing the Layer 2 beacon period somewhat offsets the impact of high speed by the MH being able to detect the new AP and start Layer 2 setup earlier. This results in a smaller probability of packets being sent to an outdated location and getting dropped by the ARs.

IV. CONCLUSIONS

This paper evaluated the impact of Layer 2 setup on different performance measures of SIGMA, including overall handover latency, packet loss and throughput (although partial results have been shown in this abstract). Our results show that SIGMA handover 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.

REFERENCES

- [1] C.E. Perkins (editor), "IP Mobility Support." IETF RFC 3344, August 2002.
- [2] R. Koodli (editor), "Fast handovers for Mobile IPv6." IETF DRAFT, draft-ietf-mipshop-fast-mipv6-03.txt, October 2004.
- [3] H. Soliman, C. Catelluccia, and K.E. Malki et al., "Hierarchical Mobile IPv6 mobility management (HMIPv6)." IETF DRAFT, draft-ietf-mipshop-hmipv6-04.txt, December 2004.
- [4] 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.
- [5] 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.
- [6] 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.
- [7] S. Fu and M. Atiquzzaman, "SCTP: State of the art in research, products, and technical challenges," *IEEE Communication Magazine*, vol. 42, no. 4, pp. 64–76, April 2004.