Fast End-to-End Mobility Support Using SIP for Vertical Handoffs in 4G Wireless Communication Networks

Jung-Ho Lee, Sang-Hee Lee, Ki-Nam Seo, and Jae-Sung Lim

Graduate School of Information and Communication, Ajou University,

San 5, Wonchon-dong, Paldal-gu, Suwon 442-749, Korea

jackdl@hanmail.net, {dreami, knseo, jaslim}@ajou.ac.kr

Abstract. The mobility management is a significant issue in 4G heterogeneous networks. However, the mobility needs to be managed by upper layer in the networks because of the limitation of mobility management at link layer. Session Initiation Protocol (SIP) supports personal mobility so that a user can be found independent of location and network device. But it cannot support IP mobility and cannot maintain TCP connection when mobile node (MN) moves between different subnets during a session. In this paper, we propose a new mobility management scheme based on SIP to overcome mobility support problems of SIP. In the proposed scheme, an MN early gets an IP address that will be used in a new subnet and informs its correspondent node (CN) of the address. To minimize packet losses, the MN freezes data transmission during a handoff. The proposed scheme is compared with the previous mobility management scheme through computer simulations.

1. Introduction

With the start of 3G wireless services, people in both academia and industry have begun to show more and more interests in 4G wireless communications. The 4G mobile communication systems are characterized by heterogeneous access networks and IP-based transport technologies. The systems also provide voice and multi-media services as well as ultra-high speed Internet based on All-IP network. So, the systems have to support not only horizontal handoffs but also vertical handoffs, global roaming, and seamless services with service negotiation including mobility, security, and QoS. But, the global mobility between different access networks should be managed by upper layers because the mobility support of link layer has limitations.

SIP[1], a signaling protocol, was accepted for the next-generation standards in both cdma2000 and UMTS 3G wireless networks[2]. Also, it has been developed as a solution for mobility management of the application layer for real-time services.

[3] proposed to extend SIP with functions that would support the terminal mobility, alleviating some of the shortcomings associated with Mobile IP and its route optimization variants. It can apply over UDP, but it can not support TCP. Supporting terminal mobility for TCP with SIP requires a tracking agent on MN to maintain a record of its ongoing TCP connection, as well as, IP encapsulation capability on CN[4]. But, when an MN moves into another subnet, packet losses cannot be inevitable because of time delay that the MN is assigned with a new IP address and informs the CN of the IP address. Also, the regular TCP tuned to perform well in traditional wireline networks leads to significant throughput degradation in the mobile networks because packet losses usually occur due to handoffs rather than congestions.

In this paper, we introduce a new mobility management scheme using SIP for vertical handoffs in wireless communication networks. The proposed scheme supports route optimization and minimizes network costs by providing fast SIP mobility control for movement of MN with a TCP connection. Also, the scheme can guarantee QoS by minimizing packet losses during the handoff because of being based on the TCP freeze scheme. As a result of the simulation, the proposed scheme showed better performance in terms of throughput than the previous scheme using SIP.

The rest of this paper is organized as follows. In the next section, we mainly present operations of fast end-to-end mobility support using SIP. Then we evaluate performance of the proposed scheme by computer simulations in section 3. Finally, concluding remarks are given in section 4.

2. Fast End-to-End Mobility Support Using SIP

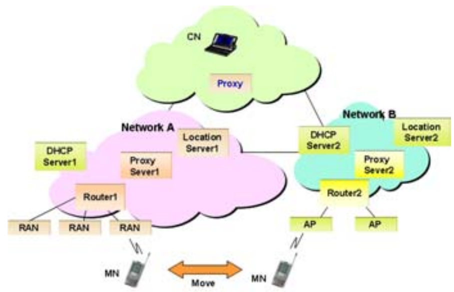

Fig. 1. Network model for proposed scheme

A network model for the proposed scheme is shown in Figure 1. This model allows for loosely coupled interworking. It also can be evolved into networks with tight coupled interworking in heterogeneous networks[5]. The MN should support dual mode that can detect two different frequencies. In the paper we don't consider Authentication, Authorization, and Accounting (AAA) between different network providers. A location server (LS) stores Access Network Identifiers (ANIDs) which are used as a layer 2 trigger to identify network areas and information of serving MNs. In this paper, SIP INFO[6] message is appropriately used to send handoff information.

As depicted in Figure 2, the proposed scheme is operated for vertical handoffs. At first, if an MN moves into a boundary of the domains, it receives ANID from the AP in the handoff zone. The MN sends this information to the proxy server 1 (PS1) in the current service area after putting the information in the body part of SIP INFO message. At this time, the SIP INFO message contains the SIP ID of the MN in From and To fields. Receiving this message, the PS1 asks the LS whether this ANID is one of areas which the PS1 manages. If the PS1 can not manage the area, it will reply with the information of other PSs around itself. Receiving the reply, PS1 forwards the ANID to surrounding PSs for searching the network with the same ANID. If a PS which manages the area of the ANID receives it, the PS gets a new IP address which the MN will use in the area by a DHCP server and sends the IP address to the MN. At the time, the IP address is delivered to the MN being contained in body part of the SIP INFO message. As soon as the MN is assigned with the new IP address, the SIP module on the MN signals its TCP, the ACK is sent to the sender(CN) with the advertised window field set to zero, and the sender enters the persist mode. On sending the ACK with the advertised window field set to zero, the MN informs the CN of the new IP address by sending SIP INFO message. After the MN moves to the target network and establishes an air link, it sends an SIP INFO message representing completion of handoff to the CN. Then as the MN sends the ACK with advertised window field set to the previous value, the sender can come out from the persist mode.

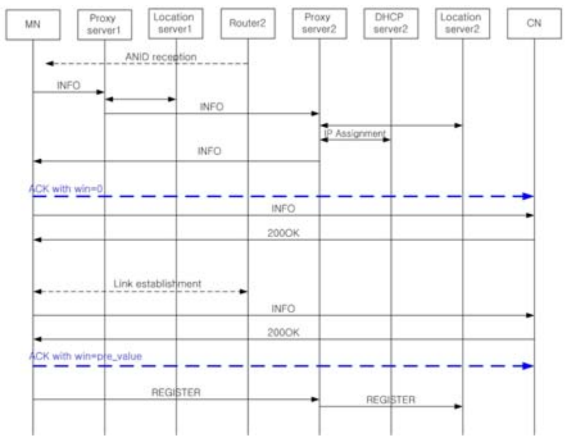

Fig. 2. Message flow in proposed scheme

3. Performance Analysis

In this paper, NS-2 was used for computer simulations[7]. We made a comparison between the proposed scheme and the previous mobility management scheme[4]. The simulation model is shown in Figure 3. The numbers beside a link indicate the bandwidth and delay of the link. We assume that an MN moves around between four domains, and one FTP connection from the CN to the MN is considered. It is also assumed that one of 4 domains is a hot spot area and others are cellular networks.

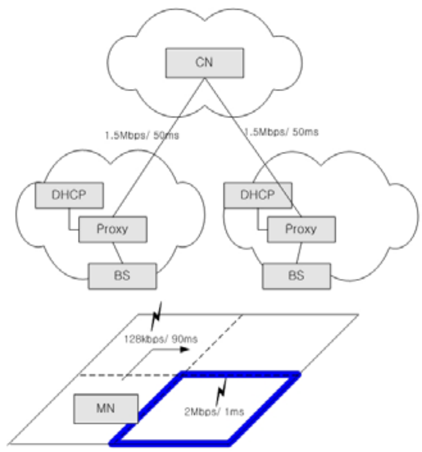

Fig. 3. Simulation Model

Figure 4 shows the throughput of the proposed scheme and the previous scheme according to average velocity of the MN. It is shown that the proposed scheme can overcome significant degradation in throughput of TCP because it freezes data transmission during vertical handoffs. As the average velocity is increased from 20km/h to 120km/h, the throughput is decreased because the faster the MN is, the more the MN crosses handoff zones.

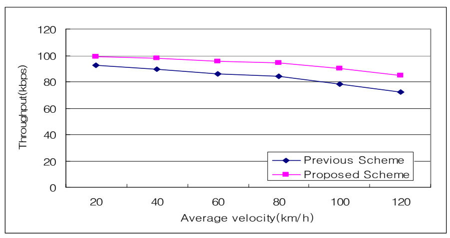

Fig. 4. Throughput according to average velocity of MN

Figure 5 shows the throughput according to increase of wired link delay when the average velocity of the MN is 50km/h. As the wired link is longer, the throughput is decreased because the time that the CN receives a new IP address from the MN becomes longer. As a result, the proposed scheme shows better throughput than the previous one.

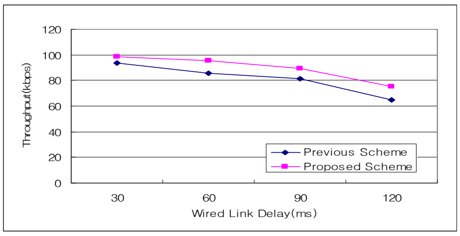

Fig. 5. Throughput according to wired link delay

4. Conclusion

In this paper, we have proposed a fast end-to-end mobility management scheme using SIP for vertical handoffs in 4G wireless communication networks. In the proposed scheme, an MN early obtains a new IP address that will be used after handoff and it makes TCP sender freeze data transmission to avoid timeout and slow start during vertical handoffs. So, the proposed scheme can guarantee QoS by minimizing packet loss. As results of computer simulations, it was shown that the scheme yielded better performance than the previous scheme using SIP.

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