

Seamless Handover Scheme based on SIP in Wireless LAN

Kam Yong Kim*, Kyeong Gon Ham*, Kee Seong Cho**, Seong-Gon Choi*

*College of Electrical & Computer Engineering Chungbuk National University (CBNU), 410 Seongbong-ro, Heungdeok-gu, Cheongju-si, Chungbuk-do, Republic of Korea

**Electronics and Telecommunications Research Institute (ETRI), 138 Gajeongno, Yuseong-gu, Daejeon, Republic of Korea
kamyong@cbnu.ac.kr, iwutopia@cbnu.ac.kr, chokis@etri.re.kr, sgchoi@cbnu.ac.kr

Abstract— In this paper, we propose L3 handover scheme using SIP messages to minimize handover latency and packet loss in a MN with single interface. Packet loss and handover latency arise from L2/L3 association delay and IP configuration delay when the MN transfers internet connectivity from the serving access router to the target access router using legacy terminal mobility mechanisms. Therefore, seamless handover is not provided by these problems such as long latency time and packet loss. In the Proposed scheme, the MN restricts that the CNs transmit packets to MN during handover procedures. Also, P-CSCF configures IP address previously for the MN in target WLAN by using CARD mechanism, and then performs registration procedures to IMS server instead of MN. And changed information about ongoing session is notified to both MN and CNs by P-CSCF. Finally, the MN communicates with CNs after transferring internet connectivity from the serving access router to the target access router. The proposed scheme reduces handover latency, particularly delay of IP address configuration. And packet loss is minimized by restriction of sending packets during handover procedures. We numerically analysed handover latency and signalling cost of the proposed scheme to show the improved performance.

Keywords— Seamless handover, mobility, SIP, WLAN, Candidate Access Router Discovery

I. INTRODUCTION

The needs of data service are increasing rapidly by increase in the number of the mobile subscribers and supply of a variety of smartphone. The IP Multimedia Subsystem (IMS) defined by the 3GPP for mobile networks of third generation represents today the global service delivery and session control platform. It was created given the necessity to bring internet services and session control to the telecom environment and also with the tendency of changing Circuit Switched(CS) to Packet Switch(PS) for allowing fast access to the data networks and to services that these offer. The 3GPP has defined the Voice Call Continuity(VCC) specifications in IMS release 7 in order to describe how a voice call can be persisted between CS and PS. And it expanded to IMS Centralized Service(ICS) and IMS Service Continuity(ISC) to provide service continuity for multimedia services in variety of access networks. And these studies are ongoing to make inter-terminal service continuity [1][2].

However, the VCC is a service continuity scheme in a single voice call. And the ISC only can support handover to multiple interfaces terminal that is possible to communication with IMS core network via different access networks at the same time. However, it is impossible to access different access network simultaneously in single interface terminal. Therefore, the terminal which using ISC for service continuity required multiple interface or multiple access status into networks by using single interface. These days, dual interface terminal which can be access 3G and WLAN are being widely used, and it is able to provided service continuity under ISC scheme. However, some users only want to use data service in WLAN because the cost of WLAN is cheaper than 3G [3-7].

To support handover in single interface terminal, many kinds of scheme are studied based on Mobile IP. However, Mobile IP based handover schemes incurred packet loss during binding update procedure, triangle routing problem, and system overload due to tunnelling process. In addition, it is difficult to control the ongoing session on IMS. Because IMS should know currently using IP address of the terminal such as Care-of-Address(CoA), but Mobile IP based schemes are given Home of Address(HoA) of the terminal to IMS instead of CoA [8].

In this paper, we propose L3 handover scheme using SIP messages to minimize handover latency and packet loss in Mobile Node(MN) with single interface. In the proposed scheme, MN restricts Correspondent Nodes(CNs) transmit packets to MN during handover procedures. Also, P-CSCF configures IP address previously for MN in target WLAN by using Candidate Access Router Discovery mechanism(CARD), and then performs registration procedures to IMS server instead of MN. And changed information about ongoing session is notified to both MN and CNs by P-CSCF. Finally, the MN communicates with CN after the transfer internet connectivity from serving access router to target access router.

The remainder of this paper is organized as follows. Section 2 describes the related works about SIP interworking with Mobile IPv6, IMS Service Continuity, and Candidate Access Router Discovery. Next, section 3 presents the proposed scheme. Then, section 4 shows the result of performance analysis. Finally, conclusions are given in section 5.

II. RELATED WORKS

A. SIP Interworking with Mobile IPv6

Both MIPv6 and SIP support mobility of Mobile Node. However, the two types of mobility are rather different [8].

MIPv6 has been designed network-layer terminal mobility and hides mobility from upper layers. In this way the mobility of the user is transparent to the upper layer protocols like those in the transport and application layer.

SIP is a protocol for establishing peer-to-peer IP communication. The elements of a network running the SIP are the user agent, proxy server, redirect server and registrar. These elements support communications between SIP peers through user tracking, call routing, and so on.

Figure 1 shows the procedure of handover using SIP interworking with Mobile IPv6.

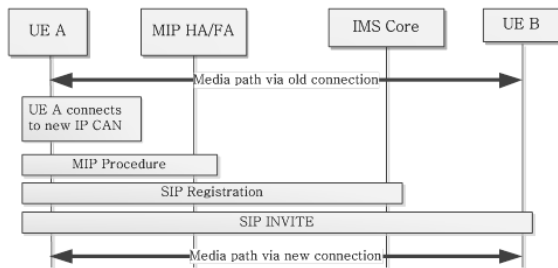


Figure 1. MIP and SIP interworking procedure

When a MN decides handover, the MN is connected with target network. Next, the MN performs MIP procedures. Then, the MN performs SIP registration with IMS core. Next, the MN sends INVITE message to the CN for renewal of session condition.

However, Mobile IP based handover schemes are incurred packet loss during binding update procedure, triangle routing problem, and system overload due to tunnelling process.

B. IMS Service Continuity

Figure 2 shows the procedure of inter PS-PS access transfer in IMS Service Continuity (ISC).

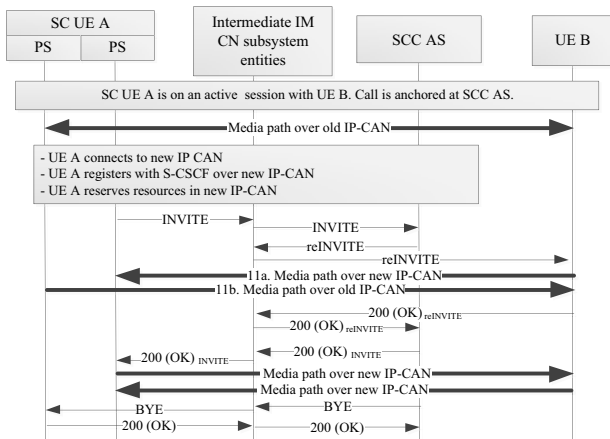


Figure 2. Inter PS-PS Access Transfer in IMS Service Continuity

To change the media path, the UE A send SIP INVITE request over target access network to Service Centralization and Continuity Application Server (SCC-AS). And SCC-AS acts as Back-to-Back User Agent(B2BUA) for the session transfer. Next, SCC-AS sends SIP reINVITE request to UE A and UE B. After receiving SIP message, both UEs change their media path from old connection to new connection. And then, SCC-AS send SIP BYE message to UE A's interface related to old media path. Then, UE A disconnects IP connection on old media path [2].

However, ISC only can support handover to multiple interfaces terminal that is possible to communication with IMS core network via different access networks at the same time. But, it is impossible to access different access network simultaneously in single interface terminal.

C. Candidate Access Router Discovery

The Candidate Access Router Discovery(CARD) protocol is designed for use in wireless IP networks to dynamically collect information about neighboring access routers and their capabilities. This capability enables the MN to dynamically execute low-latency handoffs and to intelligently select a target access router [9].

Figure 3 illustrates a scenario of the centralized CARD operation. First, Access Routers(ARs) have registered there address information with a CARD server in advance. When a MN discovers the L2 ID of Access Point(AP) during L2 scanning, it passes one or more L2 IDs to its AR 1, and the AR 1 resolves them to the IP address of the AR 2. For this, the AR 1 checks whether the mapping information is locally available in its CAR table. If it is not, the AR 1 queries a CARD server with the L2 ID of AR 2. In response, the CARD server returns the IP address of AR 2 to the AR 1. Then, the AR 1 requests capability information of AR 2. Then, the AR 1 passes the IP address of the AR 2 and associated capabilities to the MN.

Through these procedures MN configures IP address previously which use in target access network by using CARD. And a variety of mobility schemes have studied using CARD and pure mobility schemes such as Fast Mobile IP for reducing handover latency and packet loss [11].

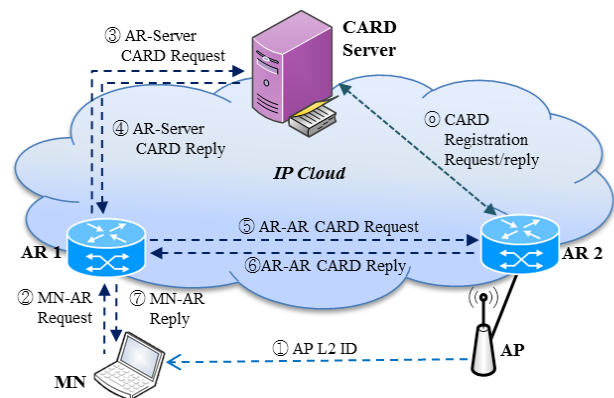


Figure 3. CARD Mechanism

III. PROPOSAL

This section presents the network configuration and message flows of the proposed scheme for terminal mobility between different WLAN domains. The proposed scheme configures IP address, which uses in target WLAN, before session transfer for the MN by using CARD. And the proposed scheme performs SIP based mobility procedure for session transfer.

Figure 4 shows the architecture of the proposed scheme.

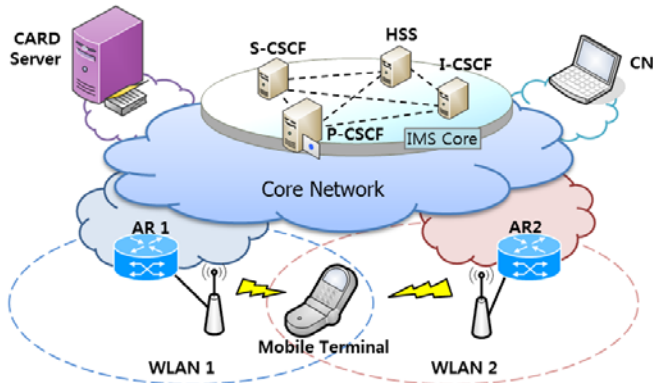


Figure 4. Architecture for the network of proposed scheme

Mobile Terminal is in an active session for media transfer with the CN via AR1. A message flow for session establish for call setup can be found in pure SIP protocol [12].

We focus on handover procedure in this paper. When mobile terminal changes access network from AR1 to AR2, Figure 5 shows the procedure of handover using proposed scheme. In figure 5, originating terminal means the mobile terminal, and terminating terminal means the correspondent node.

First, originating terminal is in an active session with terminating terminal via AR1. And originating terminal's geographical location has been changed AR2's area from AR1's coverage. In this case, the handover is required to originating terminal. And we assumed that originating terminal decides to transfer the session over the AR2. Originating terminal obtains a L2 ID of AR2 that it will use for CARD procedure. The L2 ID of AR2 is typically discovered during an operation by the originating terminal. Originating terminal receives the L2 beacons of the AR2 and informs the P-CSCF of the L2 ID included in the beacons of AR2 and request of invite using SIP REFER message. The SIP REFER message includes a L2 ID of originating terminal, the L2 ID of AR2, invite request, describe the session for 'sendonly', and other information.

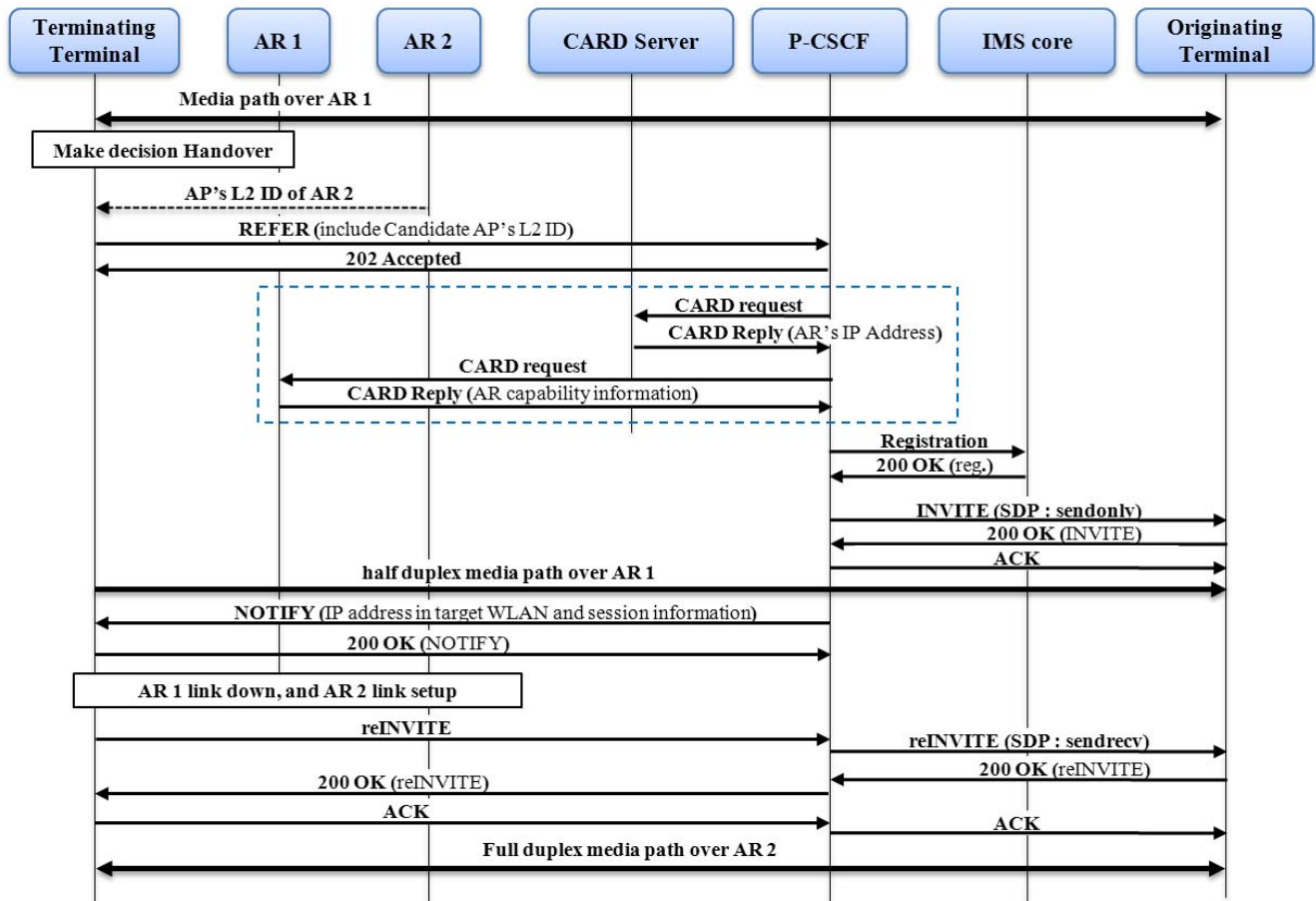


Figure 5. Proposed handover procedure

When P-CSCF receives REFER message, P-CSCF queries a CARD server with the L2 ID of AR2. In response, the CARD server returns the IP address of the AR2 to P-CSCF. Then, P-CSCF directly contacts AR2 and performs capability discovery with it.

Next, P-CSCF determines originating terminal's link-local IPv6 address from the contents of received REFER messages, using originating terminal's interface ID. And P-CSCF determines originating terminal's global address which use in AR2 network from the contents of received CARD reply, using EUI-64 standard to define the network ID portion of the address, it is reasonable to assume the uniqueness of the host address on the link. This process is defined RFC 2462 named 'IPv6 stateless auto-configuration' [13].

After address configuration of originating terminal, P-CSCF performs REGISTRATION procedure for originating terminal. And P-CSCF sends INVITE request to terminating terminal. This INVITE request include 'sendonly' message which describes that session is changed inactive mode. Then, terminating terminal stops sending packets to originating terminal, and sends 200 OK message to P-CSCF.

Next, P-CSCF sends NOTIFY message to originating terminal in response to REFER message. This message includes originating terminal's IPv6 address for communication in AR2 network.

Now, originating terminal disconnects wireless link connection from AR1 and connects to AR2 network using pre-configured address. In this case, terminal only performs physical-layer association with AR2. Then, originating terminal sends reINVITE request to terminating terminals immediately. This request includes 'active' message which describes that session is changed on active mode. So, originating terminal communicates with terminating terminal after the transfer internet connectivity from AR1 network to AR2 network.

Handover latency, particularly delay of IP address configuration can be reduced by using proposed scheme. And it is minimized packet loss by restriction of sending packets during handover procedures.

IV. PERFORMANCE ANALYSIS

This section presents the performance analysis for the existing and proposed scheme. We numerically analyse handover latency and signalling cost taken for SIP interworking with MIP and proposal scheme.

A. Signalling Cost

We compare the signalling cost of our proposed scheme and SIP interworking with MIP scheme.

The signalling costs incurred by message i each time are defined as the product of the message's length and the distance message i traverses between the source node and the destination node in the network [8].

In the SIP interworking with MIP scheme, the signalling cost consists of SIP message, MIP message and DHCP message. Thus, signalling cost of SIP interworking with SIP scheme is given by

$$C_{SIP\&MIP} = P_{active} \cdot \lambda m \cdot \sum_i \{ (L_{SIP} + L_{MIP} + L_{DHCP}) \cdot distance_i \}, \quad (1)$$

And the signalling cost of proposed scheme consists of SIP message and CARD message. Thus, we have

$$C_{Proposal} = P_{active} \cdot \lambda m \cdot \sum_i \{ (L_{SIP} + L_{CARD}) \cdot distance_i \}, \quad (2)$$

Table 1 lists the input parameters and their typical values or expressions adopted in the subsequent numerical analysis. In addition, $\lambda s / \lambda m$ and $\lambda s / \mu$ are known as call-to-mobility rate (CMR).

Table 1. Parameters for Signalling Costs analysis [4] [8] [9]

Symbol	Input Parameter	Value
L_{SIP}	Length of SIP message	400 bytes
L_{MIP}	Length of MIP message	80 bytes
L_{CARD}	Length of CARD message	100 bytes
L_{DHCP}	Length of DHCP message	100 bytes
a	End-to-End distance between MN/CN and CSCF/HA	10 hops
b	End-to-End distance between MN and CN	20 hops
c	End-to-End distance between CSCF and AR/CARD server	10 hops
d	End-to-End distance between CSCFs	5 hops
e	End-to-End distance between MN and DHCP server	2 hops
λm	Mean inter-domain movement rate	$4h^{-1}MN^{-1}$
λs	Mean session(call) arrive rate	$2h^{-1}MN^{-1}$
μ^{-1}	Mean session(call) holding time	1/20h(3min)
P_{active}	Probability that an MN is in the active mode when an inter-domain movement occurs	$\lambda s \cdot (\lambda s + \mu)^{-1}$

From Eq. (1) and (2), the total signaling costs of each scheme is presented in Table 2.

Table 2. Expression for signalling costs

Scheme	Expression
$C_{SIP\&MIP}$	$P_{active} \cdot \lambda m \cdot (4aL_{SIP} + 3bL_{SIP} + 2aL_{MIP} + 4eL_{DHCP})$
$C_{Proposal}$	$P_{active} \cdot \lambda m \cdot (4dL_{SIP} + 13aL_{SIP} + 4cL_{CARD})$

Figure 6 show the proposed scheme's signalling cost is higher than one of SIP interworking with MIP.

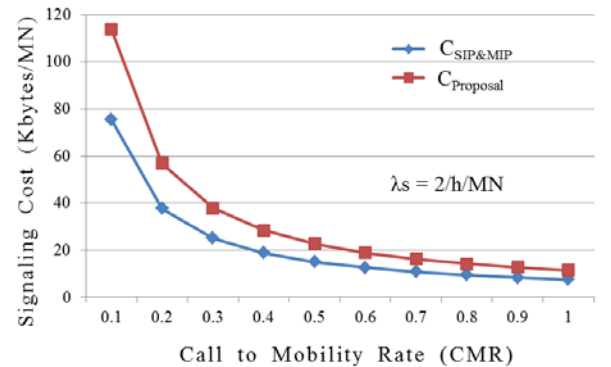


Figure 6. Impact of CMR on Signaling costs

B. Handover Latency

The handover latency is defined as the time interval during which a MN cannot receive and transmit any packet due to the handover procedure [4-6].

The handover latency consists of L2 switching delay(D_{L2}), IP connectivity latency(D_{L3}), and signalling delay($D_{SIGNALLING}$) for handover. Therefore, we have

$$D_{TOTAL} = \sum D_{SIGNALLING} + D_{L2} + D_{L3}, \quad (3)$$

where the parameters are defined as Table 2.

Table 3. Parameters for Handover Latency Analysis [5]

Symbol	Parameter	Value
D_{L2}	L2 handover delay	50ms
D_{FL3}	IP connectivity latency (with CARD)	100ms
D_{SL3}	IP connectivity latency (with DHCP)	600ms
t	One-way delay between nodes	20ms

In the SIP interworking with MIP scheme, the handover latency consists of $\sum D_{SIGNALLING}$, D_{L2} and D_{SL3} which includes IP address acquisition such as DHCP method. $\sum D_{SIGNALLING}$ is defined as the sum total of product of the signalling message and the one-way delay between nodes. Thus, we have

$$D_{SIP\&MIP} = 8t + D_{SL3} + D_{L2} \quad (4)$$

In the proposed scheme, CARD operation is required for IP address acquisition instead of DHCP method. Thus, we have

$$D_{P(CALLER)} = 2t + D_{FL3} + D_{L2}$$

$$D_{P(CALLEE)} = 5t + D_{FL3} + D_{L2}$$

$D_{P(CALLER)}$ is the handover latency of caller side and $D_{P(CALLEE)}$ is the handover latency of callee side in proposed scheme.

Figure 7 shows the proposed scheme's handover latency time is lower than one of SIP interworking with MIP.

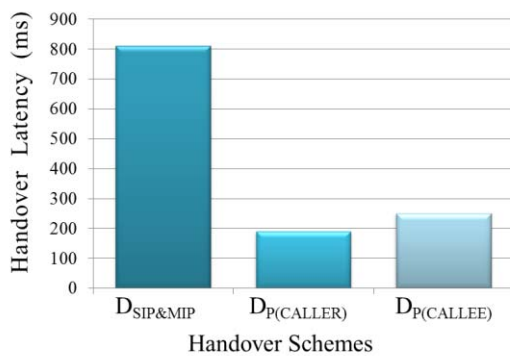


Figure 7. Handover Latency Time

V. CONCLUSIONS

This paper proposes L3 handover scheme using SIP messages to minimize handover latency in a terminal with

single WLAN interface. For the performance comparison between existing and proposed scheme, we calculated handover latency and signalling cost of two schemes. As a result of numerical analysis, the signalling cost of the proposed scheme is increased by 50% compared to existing, but the handover latency is decreased by over 70%. In addition, the proposed scheme restricts terminating terminal to send data during handover procedures. For this, packet loss will be reduced. The handover performance can be measured as handover loss and latency. It is clear that proposed handover scheme can reduce the handover latency and packet loss, compared to the SIP interworking MIP handover.

In our future works, we may consider and define more correct parameter values for performance evaluation and simulation.

ACKNOWLEDGMENT

The work was supported by the IT R&D program of KEIT& MKE&KCC, Rep. of Korea. 2009-S-026-01, Development of Group Service and Service Continuity Control Technology in the Broadcast and Tele-communication Converged Environment

†Corresponding author: Seong Gon Choi (sgchoi@cbnu.ac.kr)

REFERENCES

- [1] 3GPP TS 23.228, V10.0.0, "IP Multimedia Subsystem (IMS)," 2010.
- [2] 3GPP TS 24.237, V9.3.0, "IP Multimedia Subsystem (IMS) Service Continuity," 2010.
- [3] Myoungju Yu, Jongmin Lee, Tai-Won Um, Won Ryu, Byung Sun Lee and Seong Gon Choi, "A New Mechanism for Seamless Mobility Based on MPLS LSP in BeN," IEICE TRANS. COMMUN., vol. E.91-B, no. 2, pp. 593-569, 2008.
- [4] R. Mahmood, Azad, and A. M., "SIP messages delay analysis in heterogeneous network," IEEE ICWCSC 2010, 2010.
- [5] Jui-Hung Yeh, Jyh-Cheng Chen, Prathima Agrawal, "Fast Intra-Network and Cross-Layer Handover (FINCH) for WiMAX and Mobile Internet," IEEE TRANSACTIONS ON MOBILE COMPUTING, Vol. 8, pp.558-574, Apr. 2009.
- [6] N. Montavont, T. Noel, "Analysis and Evaluation of Mobile IPv6 Handovers over Wireless LAN," Mobile Networks and Applications, vol. 8, no. 6, pp. 643-653, 2003.
- [7] N.Banerjee, W. Wu, K. Basu, and S. Das, "Analysis of SIP-Based Mobility Management in 4G Wireless Networks", Elsevier Computer Comm., vol. 7, no. 8, pp. 697-707, 2004.
- [8] Qi Wang and Mosa Ali Abu-Rgheff, "Mobility Management Architectures based on Joint Mobile IP and SIP Protocols," IEEE Wireless Communications, vol. 13, no. 6, pp. 68-76, 2006.
- [9] M. Liebsch and A. Singh, "Candidate Access Router Discovery (CARD)," IETF, RFC 4066, 2005.
- [10] R. Chandra, J. Padhye, L. Ravindranath, and A. Wolman, "Beacon-Stuffing: Wi-Fi without Associations", Mobile Computing Systems and Applications, HotMobile 2007. Eighth IEEE Workshop on, 2007.
- [11] Robert C., Chalmers, Govind K. and Kevin C., "Enabling Intelligent Handovers in Heterogeneous Wireless Networks", Mobile Networks and Application, vol. 11, no. 2, pp. 215-227, 2006.
- [12] M. Handley, H. Schulzrinne, E.Schooler, and J. Rosenberg, "SIP : Session Initiation Protocol", IETF, RFC 2543, 1999
- [13] S. Thomson and T. Narten, "IPv6 Stateless Address Auto-configuration", IETF, RFC 2462, 1998.