Integrating SIP with F-HMIPv6 to Enhance End-to-End QoS in Next Generation Networks

Muhammad Zubair[1], Xiangwei Kong[1], Irum Jamshed[2], and Muhammad Ali[2]

[1] School of Communication and Information Engineering,
Dalian University of Technology, Dalian, China
m.zubairpaf@gmail.com,
kongxw@dlut.edu.cn
[2] Center of Excellence in Information Technology,
Institute of Management Sciences, Peshawar, Pakistan
irum.jamshed@gmail.com,
muhammad.ali@imsciences.edu.pk

Abstract. With the advancement in communication technologies, user's demand continuously increases while moving across diverse networks. The research community is putting their best efforts in the deployment of Next Generation Networks (NGNs). The primary goal of NGNs is to provide Always Best Connected (ABC) services. Researchers' current focus is on many issues such as support for multicasting and QoS, security, resource management and allocation, location coordination and handoff. In such a heterogeneous environment, ensuring the end-to-end QoS is a challenge. The problem in combining Session Initiation Protocol (SIP) with Mobile IPv6 and Seamless MIPv6 is that the traffic goes through core network every time the call/ sessions are established, resulting into very high delay and overhead on core networks. In this paper, integrating SIP with Fast handover for Hierarchical Mobile IPv6 (ISF) is proposed which utilizes the balancing capabilities of each protocol and endeavors at dropping their practical dependencies. ISF ensures end-to-end QoS for multimedia session as well as minimizing the signaling traffic between edge and core networks, service disruption, and user authentication. The conducted results show that our proposed scheme outperforms the existing approaches in terms of handover latency, packet loss, and packet load.

Keywords: Fast Hierarchical Mobile IPV6, Next Generation Network, Session Initiation Protocol, End-to-end QoS.

1 Introduction

In the present age of communication, new mobile devices such as Apple's iPhone, Google's NexusOne, Android, Laptop and PDAs are becoming progressively popular and extensively used. This trend will increase in the near future. These devices contain multiple wireless network interfaces such as Bluetooth, Wi-Fi, WiMAX, Wireless Broadband (WBro), WLAN, 3G and 4G Mobile networks. Mobile users will

J. Świątek et al. (eds.), *Advances in Systems Science*,
Advances in Intelligent Systems and Computing 240,
DOI: 10.1007/978-3-319-01857-7_68,

experience cost effective IP-based advanced real time applications such as VoIP, mobile games, mobile APTV, Emergency Telecom Services (ETS), Voice 2.0 and much more [1].

Over the past few years QoS and mobility in wireless networks has grasped researchers' attention. The growing demands and expectations of users for being connected are increasing due to which a lot of research is happening in this area. Wireless networks have evolved over last few years from the rudimentary level analog based First Generation (1G) networks to more efficient and digital Second and Third Generation (2G & 3G) networks. As a result, we are now stepping into Next Generation Networks (NGNs) also called Future Networks [2]. The goal of NGNs is to provide the users with Always Best Connected (ABC Concept) facility [3].

NGNs are based on "All IP based paradigm" that provide fully converged services, mobile access in an ambiguous manner, and support to heterogeneous devices [4]. Currently, two protocols are center of attention for supporting mobility i.e. Mobile IPv6 and SIP (Session Initiation Protocol). MIPv6 supports mobility at the network layer whereas Session Initiation Protocol (SIP) offers mobility at application layer and maintains session. Besides mobility, various problems of delay and packet loss need to be determined. To avoid these problems Fast MIPv6 [5] and Hierarchical MIPv6 [6] were introduced in which a user can be connected to more than one wireless networks at a time to acquire a smooth handover without disrupting the quality of ongoing session. In order to further minimize the handover delay, HeeYoung Jung et al. combined FMIPv6 and HMIPv6 to propose F-HMIPv6 [7]. Extensions to MIPv6 have been combined with SIP over different periods to improve QoS in NGNs [8].

The scope of this research is to provide a step forward in the provisioning of QoS and mobility transparency in NGNs. The proposed scheme of Integrating SIP with F-HMIPv6 (ISF) aims to handle the signal and traffic locally by creating a dynamic tunnel between mobility anchor point (MAP) and New Access Router (NAR), thus minimizing the extra burden on the core network.

The rest of the paper is organized as follow; section 2 deals with the background study and problem statement, section 3 discusses the proposed Integrated SIP with F-HMIPv6 (ISF), its algorithm and flowchart. Section 4 shows simulation results followed by section 5 describing conclusion and future work.

2 Related Work

2.1 Integration of SIP with MIPv6

Mobile IPv6 is considered as the Mobile IP network solution that allows the nodes to maintain reachability and ongoing connection as long as it remains connected to the Internet [8, 9]. MIPv6 avoids the concept of triangular routing and supporting the session continuity during handovers. However in this approach there is no discussion on handling multimedia session or any other delay sensitive applications [10].

2.2 Integration of SIP with SMIPv6

Integration of SIP with Seamless Mobile IPv6 (SMIPv6) was proposed to further improve QoS during handovers [3]. It reduced many problems like triangular routing, QoS while performing handovers but no detail and practical implementations are mentioned in the proposed scheme.

2.3 Integration of SIP with FMIPv6

Combining Session Initiation Protocol (SIP) with Fast Mobile IPV6 [11] in 4G networks provides real time mobility. It was proposed to reduce system redundancy and signaling exchange between edge and core networks. It handles the handover latency by foretelling and executing handovers in advance. This approach provides end-to-end Quality of Service (QoS) by using Advance Resource Management Techniques (ARMT). This technique proposes to use a QoS Manager for dynamic allocation of resources during handover when requested by the users. Problem in this approach is that every time binding updates need to go through core networks causing extra delay. Mobile Node (MN) has to wait for the acknowledgement which comes through the core network causing a half round trip delay before the packets are actually forwarded to the Correspondent Node (CN). The round-trip delay is greater when the MN is far away from the core network. Further, authentication between mobile node and correspondent node was handled by QoS manager which puts extra burden on QoS manager [10].

2.4 Integration of SIP with HMIPV6 (CSH)

The approach of Combining SIP with HMIPv6 (CSH) in NGNs provides terminal and session mobility, bandwidth management, resource reservation, user authentication and delay while establishing multimedia session [12]. However, the scheme only discusses latency due to binding updates without considering Movement Detection and CoA (Care of Address) configuration/ verification. Moreover extra delay occurs because traffic is routed through MAP (Mobility Anchor Point) [13].

The above discussion leads us to propose the following improvements regarding QoS in NGNs:

- Maintaining end-to-end QoS and reducing delay during multimedia session.
- Minimizing the signaling traffic and service disruption between edge and core networks.

3 Proposed Scheme

In this section, a new approach Integrating SIP with F-HMIPv6 (ISF) is proposed that merges F-HMIPv6--a network layer protocol with SIP-- an application layer protocol as shown in Fig. 1. The achievement of ISF ensures end-to-end QoS and minimizing delay, signaling traffic and service disruption. In order to consider fast handover a dynamic tunnel between MAP and MN is created in advance before the actual handover takes place.

The other module proposed is a QoS manager. The concept of QoS manager is taken from the research work proposed in integrating SIP with FMIPv6 [16] but with some improvements. QoS manager is responsible for managing QoS while users switching between different networks or between different regions under same network. QoS manager is focused on QoS parameters and not on the security concerns because security feature is provided by F-HMIPv6.

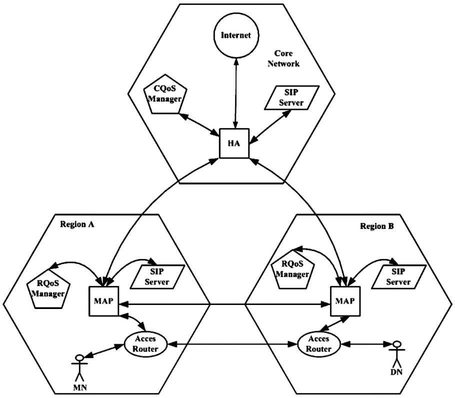


Fig. 1. Architecture of the proposed scheme

3.1 Session Initiation Protocol (SIP)

SIP is a text based and light weight application layer protocol. It provides signaling and control that is basically used for establishing, negotiating, modifying and terminating the ongoing sessions [14]. It is also used to support terminal mobility [15]. SIP is mainly concern with the session management and allows terminating of an existing or ongoing session. A user has to prior register with the SIP server before establishing a session. In the proposed scheme SIP is responsible to handle two kinds of Mobility:

Pre-Call Mobility. Pre-Call Mobility guarantees that during session or terminal mobility a CN can reach a MN. The MN, on changing its region sends its New Care of Address (NCoA) to the SIP Server of its home network. When the CN sends an INVITE message to the SIP server, it responds with the new CoA of MN. CN then sends an INVITE message to the MN and receives an Ok message from MN.

Mid-Call Mobility. Mid-Call Mobility assure the ongoing communication with its peer during handoffs. When MN initiates a handover during an ongoing session, it sends a Re-INVITE message with its New CoA. The CN replies with 200 Ok message in order to continue the session smoothly.

3.2 Fast Hierarchical Mobile Ipv6 (F-HMIPV6)

A new extension of MIPv6 called F-HMIPv6 was introduced to process the handovers in less interval of time. It is the combination of FMIPv6 and HMIPv6 that introduces the concept of creating a dynamic tunnel for fast handover between MAP and the New Access Router (NAR) [10]. MAP is a local Home Agent (HA) so there can be more than one MAP in a region. It provides the seamless connectivity by communicating with other networks before actual handover takes place. Furthermore it ensures the correct sequence of packet during handovers. It uses the concept of flush messages that helps in minimizing the delays. The main advantage of handling the mobility at network layer is that the applications are not aware of mobility.

3.3 QoS Manager

The QoS manager is responsible to allocate different resources on request of mobile users such as bandwidth allocation, implementing network policies and recourse reservation [3, 16]. In integration of SIP with FMIPv6 the security issues are handled by QoS manager [14], but in the proposed scheme it is handled by MAP which reduces the overhead on core network. In ISF architecture the QoS manager is classified on the basis of level of hierarchy as shown in Fig. 1.

Core QoS (CQoS) Manager. CQoS Manager is responsible to provide the requested resources to the Regional QoS (RQoS) manager, as their might be shortage of resources in their respected regions. CQoS manager has the ability to support handovers of different nature [14].

Regional QoS (RQoS) Manager. RQoS Manager is responsible for providing resources in their respective regions. They will maintain the communication with other RQoS managers when required during handovers.

3.4 Proposed Algorithm for Integrating SIP with F-HMIPV6 (ISF)

The proposed algorithm is designed for different networks and it includes two types of nodes: MN and Destination Node (DN). Other entity includes MAP, SIP server, Access Routers (ARs) and RQoS manager in every region. All the regions are connected with the core network. The core network has its own SIP server and CQoS manager.

ISF algorithm comprises of four different cases depending on four possible conditions that might occur during handover. The handover conditions include weak signal, user initiated handover or any other QoS issue. It also depends on session or network mobility or even both as per the user requirements.

In first case, both the MN and the DN belongs to the same region and same network. If MN or DN changes their regions under same network only the on-Link Care of Address (LCoA) will be changed.

In second case, both the MN and DN belong to the same network but different regions. If the MN or DN changes its region, the handover takes place and both the LCoA and RCoA will change. The RCoA will be updated with both HA and DN.

In third case, both MN and DN belong to different networks and different regions. If MN or DN changes its region, both RCoA and LCoA will change during handover. RCoA will be updated with the HA of that particular network and also with DN.

In fourth case, both MN and DN belong to different networks but within same region. If MN or DN changes its point of attachment, both RCoA and LCoA will change during handover. RCoA will be updated with the HA of that particular network and also with DN.

The pseudo code for the proposed scheme of Integrating SIP with F-HMIPv6 (ISF) is given as under:

```
BEGIN
1. [Connection and Session initiation]
   MN ← ARs ← MAP with strong signal
   MAP ← BU from MN
   Core Network ← BU from MAP
   DN ← BU from Core Network
   SIP Server ← MN IP address (Registration)
   SIP Server ← INVITE message from DN
   DN ← MN IP address
   DN ← MN

2. [Threshold initialization]
   TH ← MN, ARs, MAP = Value

3. [Handover Mechanism]
   WHILE (Signal Strength) < TH or User wants handover or
   any QoS issue

CASE A: DN belongs to MN region
DN ← MN = Re-Invite
MN ← DN = ok message
MN ← NAR (only LCoA will change) - through MAP
RQoS ← Managing MN and DN region resources
CQoS ← RQoS will request for resources in case of shortage in that
region.

CASE B: DN belongs to MN network AND outside MN Region
MAP ← BU from MN
Core Network ← BU from MAP
DN ← BU from Core Network
   Mid Call Mobility
MN (own region) ↔ NAR of DN through MAP
Region (both LCoA and RCoA will change)
RQoS ← managing MN and DN region resources
CQoS ← RQoS will request for resources in case of shortage in that
region

CASE C: DN belongs to different network
MAP ← BU from MN
Core Network ← BU from MAP
DN ← BU from core network
   Mid Call Mobility
MN (own network) ↔ NAR of DN through MAP
Region (both LCoA and RCoA will change)
RQoS ← managing MN and DN region resources
CQoS ← RQoS will request for resources in case of shortage in that
region

CASE D: DN belongs to different network AND within MN region
MAP ← BU from MN
Core Network ← BU from MAP
DN ← BU from Core Network
   Mid Call Mobility
MN (own network) ↔NAR of DN through MAP
Region (both LCoA and RCoA will change)
RQoS ← managing MN and DN region resources
CQoS ← RQoS will request for resources in case of shortage in that
region

4. [No handover requirement]
   Signal strength >= TH or User doesn't want handover or No QoS
issue
   then Communication will not be interrupted.
```

Complete architecture for the proposed algorithm is presented in Fig. 1. A MN in region-A wants to communicate with DN in region-B. MN will send the Binding Updates (BU) to MAP with strong signals in same region. There can be more than one MAP in a region; therefore MN will communicate with the MAP having strong signals. The BU includes both LCoA and RCoA of the MN. The connection of MN with MAP is handled through AR. The MAP will forward the BU to core network. The core network will then connect the MAP of region-A with the MAP of region-B for the first time. A session will be established between MN and DN through Core SIP server.

In case of pre call mobility, MN will send New CoA to SIP server of region-A. DN will send INVITE message to SIP Server of region-A. The region-A SIP server will forward the new CoA of the MN to the DN. The DN send INVITE message to the MN directly, and receives Ok message from MN. A session will be established known as pre call mobility.

After successful network and session connection, if handover occurs then the four different cases mentioned in the proposed algorithm will be considered to handle the network and session mobility. In any of the above discussed cases if the handover occurs, a tunnel will be created between MAP and NAR. The MAP will connect MN with DN and route the traffic between both the nodes through their ARs. A complete flow of integrating SIP with F-HMIPv6 (ISF) algorithm is presented in Fig. 2.

The RQoS manager is responsible to manage the resources in their respective region. If any shortage of resources occurs in any region a request will be made to CQoS manger. The CQoS manger will allocate resources in the requested region as per request by RQoS.

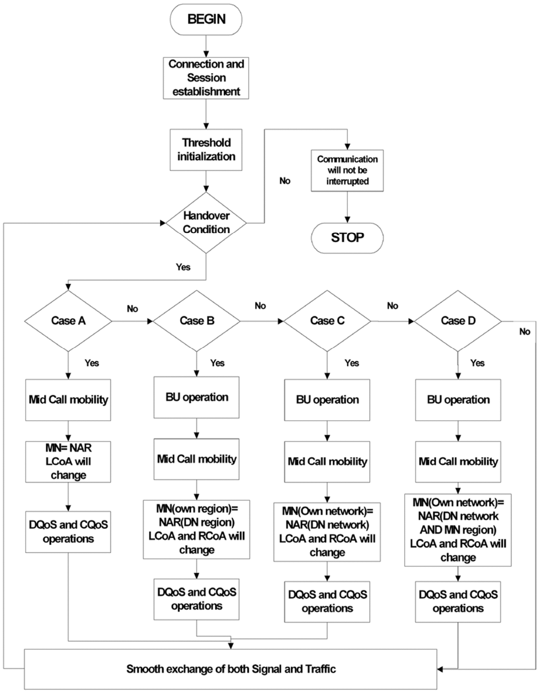


Fig. 2. Flow chart of the proposed scheme

4 Simulation Results

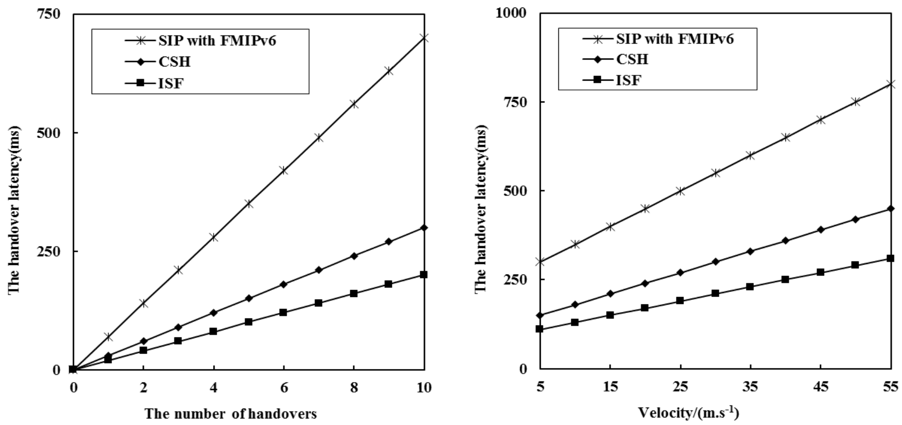
In this section, we compare our proposed scheme with the existing approaches such as integration of SIP with FMIPv6, and Combined SIP HMIPv6 (CSH). The simulation results in terms of minimizing latency, packet loss, and load are obtained through OPNET simulation tool. Various entities and nodes used in the simulation environment are presented in Fig. 1. The proposed scheme is evaluated in heterogeneous environment which includes diverse networks such as WiMAX, WLAN, and UMTS. Simulation parameters are demonstrated in Table 1.

4.1 Handover Latency

The handover latency obtained through simulation are presented is this sub section. Two cases are considered to evaluate the handover latency; one is handover latency versus velocity and the second one is handover latency versus number of handovers. In Fig. 3(a) number of handovers is kept variant for the evaluation of handover latency. Fig. 3(b) shows the increase in handover latency by increasing velocity. Our proposed scheme has 110ms to 310ms handover latency which is quietly reduced. The results demonstrates that our proposed scheme performs better than existing approaches.

Table 1. Simulation Parameters

Wired Bandwidth	1 Gb/s
Wireless link bandwidth	100 Mb/s
Packet size	1Kb
Moving speed	5-60 m/s
Radius of wireless cell	100 m
Simulation time	240 sec



(a) Handover latency versus number of handovers (b) Handover Latency versus Velocity

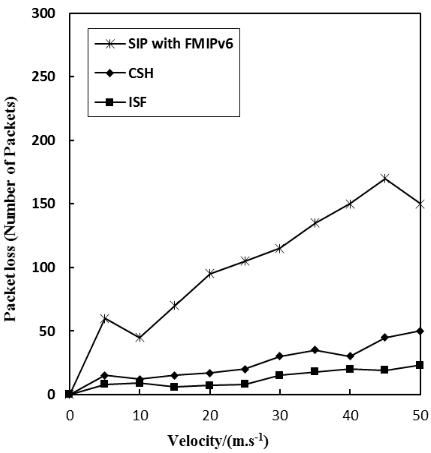
Fig. 3. Handover Latency

4.2 Packet Loss

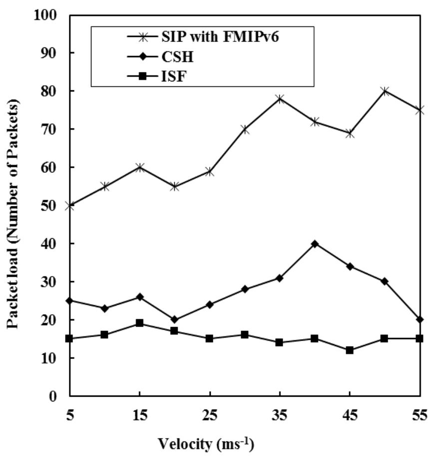
During an ongoing session, we cannot ignore the loss of packets which can be occurred due to many reasons such as improper management of bandwidth, frequently handovers, and so on. In our simulations we evaluated packet loss regarding MN velocity. In Fig. 4(a), we can observe that our proposed scheme has lower packet loss as compared to the existing approaches. The maximum packet loss obtained for SIP with FMIPv6, CSH, and ISF are 150, 50, and 23 respectively. Hence, it is justified that ISF performance is best in terms of packet of loss.

4.3 Packet Load

The traffic and signal load is evaluated for our proposed scheme and existing approaches. The load based on packet is compared by increasing velocity. We can see from Fig.4 (b), ISF has lower packet load which is less than 20, whereas in CSH it is 40. Thus. In terms of packet load, our proposed scheme outperforms SIP with FMIPv6 and CSH.



(a) Packet Loss versus Velocity



(b) Packet Load versus Velocity

Fig. 4. Packet loss/load versus velocity

5 Conclusions and Future Work

The researchers' focus is on many issues in NGNs such as wireless security, multicasting, resources allocation and management, QoS, and mobility transparency. Providing end-to-end QoS is still a challenge in heterogeneous environment. This paper proposed a new protocol Integrating SIP with F-HMIPv6 (ISF) which is a combination of an application layer protocol SIP and network layer protocol F-HMIPv6. For comparative analysis the ISF is compared with existing combination of SIP with FMIPv6, and SIP with HMIPv6. The analysis reveals that ISF aims to handle the signal and traffic locally by creating a dynamic tunnel between MAP and NAR thus minimizing the extra burden on the core network. The accomplishment of CSF includes end-to-end QoS, low signaling traffic between edge networks and core networks, to overcome the service disruption, user authentication, connection between MAP and MN is created in advance before the actual handover takes place.

In future the focus will be on security enhancement in the proposed architecture and efforts will be made to further enhance its efficiency.

References

1. Dong-Hoon, S., et al.: Distributed mobility management for efficient video delivery over all-IP mobile networks: Competing approaches. IEEE Network 27(2), 28–33 (2013)
2. Quintero, A., Frutos, E.D.: MPLS Based Architecture for Mobility and End-to-End QoS Support in Fourth Generation Mobile Networks. Journal of Computer Science 5, 255–262 (2009)
3. Faisal, S.: Performance Analysis of 4G networks. Department of Electrical Engineering School of Engineering Bleking Institute of Technology SE-37 79 Karlskrona, Sweden (2010)
4. Jesus, V., Sargento, S., Almeida, M., Corujo, D., Aguiar, R.L., Gozdecki, J., Carneiro, G., Banchs, A., Yáñez-Mingot, P.: Integration of mobility and QoS in 4g scenarios. In: Proceedings of the 3rd ACM Workshop on QoS and Security for Wireless and Mobile Networks (Q2SWinet 2007), pp. 47–54 (2007)
5. Johnson, D., Perkins, C., Arkko, J.: Mobility Support in IPv6. RFC3775, the Internet Society (June 2004)
6. Koodli, R. (ed.): Fast Handovers for Mobile IPv6. RFC4068, the Internet Society (July 2005)
7. Jung, H., Soliman, H., Koh, S.J., Takamiys, N.: Fast Handover for Hierarchical MIPv6 (F-HMIPv6). Internet Engineering Task Force (October 2005)
8. Li, Y., Zhao, Y.-S., Liu, Q.-L., Wen, F.: Performances Research of MIPv6 and extended Protocols in the process of Handover. In: Proceedings of the 5th International Conference on Wireless Communications, Networking and Mobile Computing (WiCom 2009), September 24-26 (2009)
9. Johnson, D., Perkins, C., Arkko, J.: Mobility Support in Ipv6 (MIPv6). RFC 3775, the Internet Society (June 2004)
10. Jung, H., Soliman, H., Koh, S.J., Lee, J.Y.: Fast Handover for Hierarchical MIPv6 (F-HMIPv6). Internet Engineering Task Force (April 2005)
11. Nursimloo, D.S., Kalebaila, G.K., Anthony Chan, H.: A two layered Mobility Architecture using Fast Mobile IPv6 and SIP. EURASIP Journal on Wireless Communications and Networking- Multimedia over Wireless Networks, 1–8 (2008)
12. Zubair, M., Mahfooz, S., Khan, A., Ur Rehman, W.: Providing end to end Qos in NGNs using combined SIP HMIPv6 (CSH). In: The Proceedings of the IEEE 1st International Conference on Computer Networks and Information Technology (ICCNIT 2011), July 11-13, pp. 113–118 (2011)
13. Soliman, H., Castelluccia, C., Elmalki, K., Bellier, L.: Hierarchical Mobile Ipv6 (HMIPv6) Mobility Management. RFC 5380 (October 2008)

14. Nursimloo, D.S., Chan, H.A.: Integrating fast mobile IPv6 and SIP in 4G network for real-time mobility. In: The Proceedings of the IEEE 13th International Conference on Networks, jointly held with the IEEE 7th Malaysia International Conference on Communication 2005, November 16-18, vol. 2, pp. 917–922 (2005)
15. NG, K.L.S.: Peer to Peer real time mobility using SIP and MIPv6. Electrical & Computer Engineering, National University of Singapore (2004)
16. Nakajima, N., Dutta, A., Schulzrinne, H.: Handoff Delay Analysis and Measurement for SIP based Mobility in IPv6. In: The Proceedings of the IEEE International Conference on Communications, ICC 2003, May 11-15, pp. 1085–1089 (2003)