IPv6 Mobility Support for Real-time Multimedia Communications: A Survey

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Abstract- *Mobile Internet protocol version 6 (MIPv6) route optimization improves triangular routing problem that exists in MIPv4 environment. Route optimization of Session Initiation Protocol (SIP) over MIPv6 provides efficient real-time multimedia applications to users. This article provides a survey of SIP over MIPv6. We review the processes involved during the setting up of a SIP call and during mid-call SIP mobility. When SIP transmits real-time multimedia applications in a wireless environment, the mobile node (MN) may move from one access router (AR) to another AR, handing over control from one AR to the other. High handover latency degrades the quality of real-time multimedia applications due to the fact that real-time multimedia applications are delay-sensitive. Handover latency is an important issue to discuss. Reduction of handover latency can be made possible with the use of SIP's hierarchical registration. On the other hand, hybrid hierarchical and fast handover SIP's registration performs better compared to hierarchical registration. Finally, we present the directions for future research.*

Keywords: SIP, mobile IPv6, hierarchical registration, hybrid registration

1. Introduction

The Internet carries large variety of exciting real-time multimedia applications such as streaming video, Internet Protocol (IP) telephony, Internet radio, teleconferencing, interactive games, virtual worlds and distance learning. These multimedia applications are highly delay sensitive [4]. Thus, timing considerations are important. On the other hand, real-time multimedia applications are for the most part loss tolerant.

Currently, most real-time multimedia applications are transmitted over the Internet protocol version 4 (IPv4) networks. The address allocation of IPv4 is estimated to be used up by the year 2008. The Internet Engineering Task Force (IETF) had designed Internet protocol version 6 (IPv6) in 1995 to solve the address exhaustion problem in IPv4. Other demands, which had come up within the last 20 years of using IPv4 had also been fulfilled. This bigger address space in IPv6 allows addresses to be organized in a more hierarchical ways, which speeds up the routing in the core networks.

The method of routing real-time multimedia applications in the core network can be performed in wired and wireless environment. Wireless IP also known as mobile IP (MIP) because nodes may move during communications. MIP is a flexible standard, supporting many different modes of operation, for example, operation with or without a foreign agent (FA), multiple ways for agents and mobile nodes (MN) to discover each other, use of single or multiple care of addresses (CoA), and multiple forms of encapsulation [4].

In providing efficient MIP multimedia applications to users, many researchers [1][5][9] discuss on Session Initiation Protocol (SIP) over Mobile IPv6 (MIPv6). SIP focuses on interactive multimedia sessions such as Internet phone calls or multimedia conferences. The adoption of SIP services with MIPv6 introduces the need for SIP and instant messaging to integrate with MIPv6 [1]. In addition, MIPv6 solves the problem of triangular routing in mobile IPv4 (MIPv4) [1]. Route

optimization in SIP over MIPv6 may decrease the time of handover and thus may increase the efficiency of multimedia data in wireless communications [9][2].

The rest of this article is organized in the following way. In section 2, we discuss the processes involved in the setting up of a SIP call and during mid-call SIP mobility when transmitting real-time multimedia applications. In section 3, we present the discussion on SIP over MIPv6 hierarchical registration and hybrid registration that may decrease the handover latency. Section 4 presents several research directions in this subject. Finally, section 5 concludes the article.

2. Session Initiation Protocol (SIP)

The Session Initiation Protocol (SIP) is an application layer control (signaling) protocol used for establishing and tearing down multimedia sessions, both unicast and multicast [3][8]. It is a lightweight protocol designed for the ease in transmitting real-time multimedia applications. Entities in SIP are user agents, proxy servers and redirect servers. Figure 1 shows a basic procedure of session initiation using SIP.
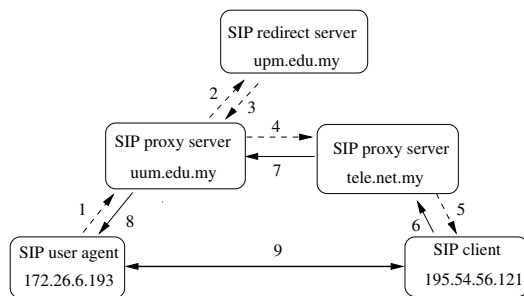

Figure 1: SIP basic procedure

In the SIP basic procedure shown in Figure 1, a call is initiated by a SIP user agent address 172.26.6.195 to SIP client address 195.54.56.121. The following steps are taken in the SIP basic procedure. (1) The SIP user agent sends an INVITE message to the SIP proxy server using uum.edu.my as the address. (2) The SIP proxy server uum.edu.my does a domain name system (DNS) lookup on the SIP redirect server using upm.edu.my as the address, where the SIP client 195.54.56.121 located. (3) Because SIP client 195.54.56.121 is no longer registered at the upm.edu.my SIP redirect server, the upm.edu.my redirect server sends a redirect response, indicating that it should try SIP proxy server ad-

dress tele.net.my. (4) The SIP proxy server uum.edu.my sends an INVITE message to the SIP proxy server address tele.net.my. (5) The tele.net.my server knows the IP address of SIP's client 195.54.56.121 and sends the INVITE message to the host 195.54.56.121. (6-8) A SIP response is sent back through redirect/proxy to the SIP user agent 172.26.6.195. (9) Media is sent directly between SIP user agent and SIP client.

SIP user agent sends real-time multimedia application to SIP client in wired and wireless environment. In wireless communication, MN may be static where it connects to the AR with stronger signal strength. MN may move to the location where no signal strength, thus disconnection occurs. In another condition, MN may move from one AR to another AR. When MN moves from one AR to another AR, it performs handover. Handover latency is an important issue to discuss in order for a MN to receive real-time multimedia applications over IP efficiently. In order to provide efficient real-time multimedia applications, researchers [1][5][9] study the performances of SIP over MIP. This integration provides better performance compared to standard MIP [10].

Having understood the importance of SIP over MIP, next we briefly discuss the processes involved during the setting up of a SIP call and during mid-call SIP mobility when transmitting real-time multimedia applications.
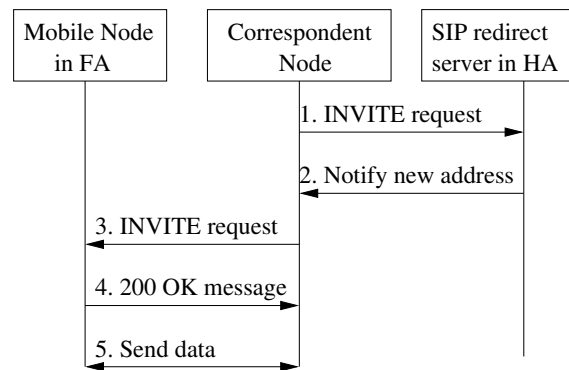

Figure 2: Setting up a call in SIP mobility

Setting up a call ensures that the correspondent node (CN) can send real-time multimedia applications to the MN. Figure 2 shows the process of setting up a SIP call. The CN intends to communicate with the MN. The following steps are taken. (1) The CN sends an INVITE request to the SIP server in home agent (HA). (2) SIP

server notifies MN's new contact address. (3) CN then sends an INVITE request to MN directly. (4) MN receives the INVITE request and sends 200 OK message to the CN. (5) CN sends data to MN.
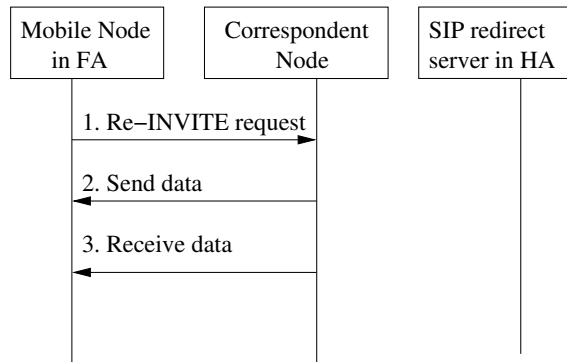

Figure 3: Mid-call SIP mobility

During real-time multimedia communications between MN and CN, MN may move from one AR to another AR. Next, we discuss on the process involves during mid-call SIP mobility. It is a process performs when MN moves from one FA to another during real-time multimedia applications. MN needs to inform CN on the changes of address. Figure 3 shows the mid-call SIP mobility that allows a node to continue an ongoing session with its peer during handover. The following steps are taken. (1) MN sends a re-INVITE request with new IP address to CN. (2) CN directly sends data to MN at the new point of attachment in the network. (3) MN receives the data and continues the communication with CN.

The process of setting up a SIP call and the process involved in mid-call SIP mobility in MIPv4 draw few weaknesses compared to that of in MIPv6. The major weakness of IPv4 is the limited addressing capability. Development of the 128-bit addressing in IPv6 expands the IPv4 32-bit addressing capability. With $3.403x10^{38}$ addressing spaces in IPv6, addressing allocation problem is solved in MIPv6. Theoretically, every single item can be allocated an IP address in the future Internet.

The second major weakness of MIPv4 is the triangular routing problem. Triangular routing is the process where packets have to pass through HA and FA before reaching the MN. A more efficient routing scheme has since been designed in MIPv6 namely route optimization [1]. The idea of route optimization is that the routes to the MNs would be improved if they hadn't to go by

the HA. This solves the triangular routing problem in MIPv4.

Figure 4 below describes triangular routing in MIPv4 and route optimization in MIPv6. Option 1 is the triangular routing process performed by MIPv4. The MN receives packets from the CN tunnelled through the HA. Then, the MN sends the packets back to the CN, tunnelled through the HA again. Imagine that CN is located besides MN. Routing the real-time multimedia applications back to HA may cause delay. In option 2, MIPv6 performs route optimization since the beginning of the real-time multimedia applications. CN directly sends data to MN. MN in FA sends a binding update (BU) to CN immediately after setting up the SIP call, before any traffic modification to the implementation of the MN.
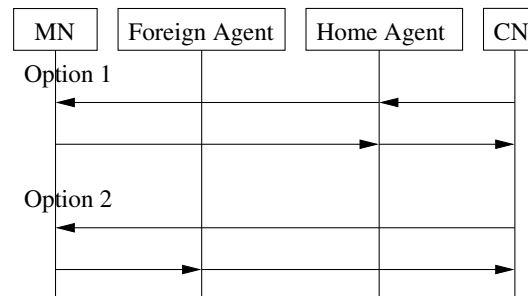

Figure 4: Triangular routing in option 1 and route optimization in option 2

Route optimization in SIP over MIPv6 solves the triangular routing problem in MIPv4. However, real-time multimedia applications are delay-sensitive. Thus, handover latency is an important issue to discuss. In the next session, we present the process of hierarchical registration in SIP over MIPv6. We also discuss on hybrid registration in SIP over MIPv6. These 2 processes may reduce the handover latency.

3. Hierarchical and Hybrid Model Registration in Mobile IPv6

In SIP over MIPv6, BUs are sent to the CN when MN changes from one AR to another AR. When the MN is far away from the CN, sending a BU to the SIP server every time it moves can place an unnecessarily high load on the SIP server and network, especially if the SIP server is serving many hosts. This may cause the handover delay.

Instead, the MN can register with a closer SIP server and the SIP server on the CN knows to which SIP server it should redirect an incoming request[6]. This may shorten the time of registration and thus may decrease the handover delay.
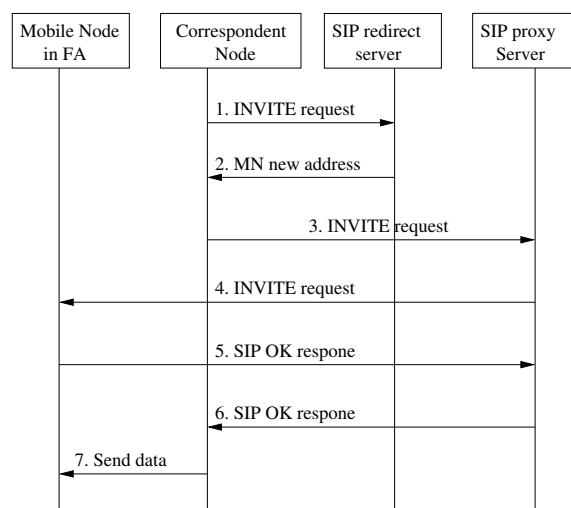

Figure 5: Hierarchical registration

Figure 5 shows the process of SIP servers in hierarchical path. The following steps are taken. (1) CN sends the INVITE message to the SIP redirect server. (2) The SIP redirect server sends the current MN address to CN. (3) CN then sends SIP INVITE message to the SIP proxy server. (4) The SIP proxy server then sends the INVITE message to MN in the FA. (5) After receiving the INVITE message, MN sends the SIP OK response message back to the SIP proxy server. (6) The SIP proxy server then sends the SIP OK response message back to the CN. (7) CN starts sending data with MN and CN starts sending data to MN.

Another operation that may reduce the handover latency is the hybrid registration in SIP over MIPv6. It is the process of combining both hierarchical and fast handover registration in SIP over MIPv6. Hybrid registration may perform better compared to hierarchical registration. Hybrid registration in SIP over MIPv6 model has the potential to reduce the impact of handover that induced packet delay on wireless real-time multimedia applications.

The goal of hybrid registration is to inform the CN for the new registration immediately after handover during transmission of real-time multimedia applications. This is accomplished by allowing the AR to send out regis-

trations on behalf of the MN. The registration list in the MN is copied to the AR. This copy is managed by the AR-proxy in the same way that the original is managed in the MN. The copy is periodically synchronized with the original.

As soon as handover event is detected and the AR has generated the new address, the following steps are taken. (1) A copy of the registration list is used to inform all the active CNs of the new address. (2) MN then sends a neighbor advertisement (NA) to the new AR to start the real-time multimedia applications flow over the new wireless link. (3) A special router solicitation for hybrid proxy message containing the registration list of the MN is sent to the new AR. (4) AR caches a copy of the current registration for this particular MN and responds with a hybrid proxy router advertisement. (5) Then, MN and CN start transmitting real-time multimedia applications.

During communications in hybrid registration, MN periodically sends router solicitation for hybrid proxy message. The reason is to synchronize the copy of the registration list cached by the new AR with the original. In addition, AR manages the lifetime of the entries in the cached copy in the same way that the MN manages the lifetime of the entries in the original list.

As discussed in the hierarchical registration, MN registers with the closest SIP server in hybrid registration. Combining fast handover and hierarchical registration, MN may perform better during the handover process.

The processes of hierarchical registration and hybrid registration in SIP over MIPv6 may reduce handover latency when MN moves from one AR to another. These processes may provide better real-time multimedia applications to the users. In the next session, we present directions for future research.

4. Research Direction

Real-time multimedia applications have become an integral part of computing and communications environment and networks are carrying ever-increasing volumes of real-time multimedia information. The main characteristics of multimedia information are high-volume and busty traffics, with less tolerance to delay and delay variance. The legacy networks (designed in 70s and 80s) are not able to meet these requirements. Enhancements to the older technologies have been developed to convert these into multimedia networks[7].

In addition, mobile communications are expected continue growing in the coming years. The need for

continued networking support for uninterrupted real-time multimedia applications are becoming increasingly important. Companies and countries are continuously improving the services to provide effective mobile real-time communications to the users.

SIP-based mobility can be used to provide all common forms of mobility, including terminal mobility, personal mobility, service mobility and session mobility [5]. .Thus, future research on SIP over MIPv6 is increasingly important to provide effective wireless real-time multimedia communications to the users.

5. Conclusion

This article presents a survey of SIP over MIPv6. The process of setting up a SIP call is discussed. It is a process that is performed when a CN intends to communicate with a MN. The process during mid-call SIP mobility is also presented. This is the process that is performed when a MN moves from one AR to another AR. In addition, the process of route optimization in MIPv6 that solves the triangular routing is also presented.

The discussion continues with hierarchical registration in SIP over MIPv6. Hierarchical registration may decrease the SIP mobility delay [9]. Hybrid registration in SIP over MIPv6 may perform better compared to hierarchical registration. Hybrid model may enable MN to perform smoother handover. With smoother handover, MN and CN exchange real-time multimedia applications efficiently in the future wireless communication.

References

[1] S. M. Faccin, P. Lalwaney, and B. Patil. *IP Multimedia Services: Analysis of Mobile IP and SIP Interactions in 3G Networks*. IEEE Communications Magazine, January 2004.

[2] J. Finney and A. Scott. *Implementing Mobile IPv6 for Multimedia*. Computing Department, Lancaster University, Lancaster, UK, 1996.

[3] M. Handley, H. Schulzrinne, E. Schooler, and J. Rosenberg. *SIP: Session Initiation Protocol*. RFC 2543, March 1999.

[4] J. F. Kurose and K. W. Ross. *Computer Networking A Top-Down Approach Featuring the Internet*. Addison Wesley, 2nd edition, 2002.

[5] N.Nakajima, A. Dutta, S. Das, and H. Schulzrinne. *Handoff Delay Analysis and Mesurement for SIP Based Mobility in IPv6*. ICC 2003 - IEEE International Conference on Communications, May 2003.

[6] H. Schulzrinne and E. Wedlund. *Application-Layer Mobility Using SIP*. Mobile Computing and Communications Review, 1999.

[7] N. Sharda. *Multimedia Network: Fundamentals and Future Directions*. Communications of the Association of Information System, February 1999.

[8] K. K. Tan and H. L. Goh. *Session Initiation Protocol*. IEEE ICT'02 Bangkok Thailand, 2002.

[9] E. Wedlund and H. Schulzrinne. *Mobility Support Using SIP*. WoWMoM 99, ACM, 1999.

[10] K. D. Wong, A. Dutta, J. Burns, R. Jain, K. Young, and H. Schulzrinne. *A Multilayered Mobility Management Scheme For Auto-Configured Wireless IP Networks*. IEEE Wireless Communications, October 2003.