A Survey of IPv6 Mobility Management in Real-time Communications

Bi-Lynn Ong, Suhaidi Hassan
Faculty of Information Technology
Universiti Utara Malaysia
Kedah, Malaysia
{s90387@ss.uum.edu.my|suhaidi@uum.edu.my}

Abstract- **The number of mobile wireless Internet users is expected to increase in recent years. Consequently, the 32-bit addressing spaces used for mobile Internet protocol version 4 (IPv4) is expected to be used up in the near future. Previous works show that mobile IPv4 causes unnecessary load to the mobile Internet. This unnecessary load increases handover latency. In this paper, we firstly discuss the hybrid Internet protocol version 6 (IPv6) mobility management. Hybrid IPv6 mobility management is the combination of fast handover and hierarchical IPv6 mobility managements. We propose the Session Initiation Protocol (SIP) over hybrid IPv6 mobility management to manage the handover process between inter-domain networks. We also propose cellular hybrid IPv6 mobility management to manage the handover process within intra-domain network. We believe that the proposed SIP over hybrid and cellular hybrid IPv6 mobility managements can solve the problem of unnecessary load and decrease the handover latency.**

Index terms- **IPv6, SIP, cellular IP**

I. Introduction

INTERNET protocol version 6 (IPv6) is the new version of Internet protocol (IP), designed as the successor of Internet protocol version 4 (IPv4). One of the main motivations of IPv6 is to increase the address spaces available for the Internet hosts. The development of 128-bit addressing spaces in IPv6 expands the IPv4 32-bit addressing spaces [2], [7]. Other motivations of IPv6 include improving routing capabilities, real-time support, security and multicasting [22].

Castelluccia [6], Kan et al. [14] and Vivaldi et al. [13] discussed the implementation of IPv6 in mobile IP. The implementation of IPv6 into mobile IP solves the lack of IP addresses in wireless environment [22]. The IPv6 mobility management enables communication networks to locate mobile users and maintain the connections as mobile users move into a new network. The goal of mobility management is to ensure continuous connectivity during the process of handover. There are 2 types of mobility management namely micromobility and macromobility managements. Micromobility or intra-domain mobility refers to the movement of mobile users across different networks within a subnet and happens very rapidly. On the other hand, macromobility or inter-domain mobility is the movement of a mobile users across different subnets and happens relatively less frequently.

IPv6 mobility management solves the addressing problem [22]. Nevertheless, IPv6 mobility management, that manages both inter-domain and intra-domain mobility, causes unnecessary load to the mobile Internet [23]. Many previous works have looked into the interworking of various protocols to overcome this problem.

IPv6 mobility management with hierarchical and fast handover mechanisms decrease the handover latency [12]. The combination of hierarchical and fast handover mechanisms, namely hybrid IPv6 mobility management, performs better compared to mobile IP [12].

Handley et al. [10] and Schulzrinne et al. [23] proposed SIP to manage inter-domain mobility management. SIP is an application layer control protocol used for establishing and tearing down multimedia sessions. When MN moves between different hierarchical networks and transmitting real-time packets, SIP over IPv6 mobility management may perform smoother handovers.

Campbell et al. [4] proposed cellular IPv6 to manage intra-domain mobility management. The cellular IPv6 approach envisions a networking environment with ubiquitous computers. Cellular IPv6 can lessen the number of binding updates (BU) that are sent to the home network (HN) and can reduces the handover latency [4].

The rest of this paper is organized as follow. Section 2 presents an overview of hybrid IPv6 mobility management, which is the combination of fast handover and hierarchical mechanisms. Further in Section 3, we discuss SIP over hybrid IPv6 mobility management in sending real-time applications. In Section 4, we present cellular hybrid IPv6 mobility management in managing micromobility management. Section 5 presents several research directions in this topic. Finally, Section 5 concludes this paper.

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II. Overview of Hybrid IPv6 Mobility Management

The basic IPv6 mobility management models were discussed in details in [14],[17], [20], [26]. Internet Engineering Task Force (IETF) has proposed IPv6 mobility managment with 128-bit addressing spaces to solve the lack of IP addresses in the future Internet [24]. In this section, we discuss hierarchical, fast handover and hybrid mechanisms used in IPv6 mobility management.

A. Hierarchical Mechanism

Hierarchical mechanism was proposed by Castelluccia [5]. The proposed hierarchical mechanism reduces handover latency. Using such a hierarchical approach has at least two advantages. Firstly, hierarchical mechanism improves handover performance because local handover is performed locally. Local handover reduces handover latency and minimizes the loss of packets that may occur during transitions. Secondly, hierarchical handover significantly reduces the mobility management signaling load on the Internet since the signaling messages corresponding to the local moves do not cross the whole Internet but stay confined to the site. Fig. 1 shows the hierarchical mechanism that improves the mobile IP performance during the process of handover [6]. This hierarchical mechanism reduces the number of BU messages sent from MN to correspondent nodes (CN) and the home agent (HA) [15].

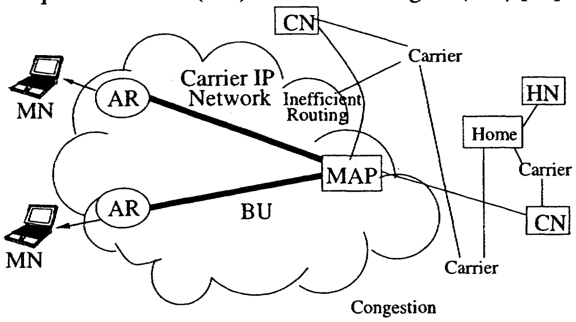

Fig. 1. Hierarchical mechanism

In Fig.1, mobility anchor point (MAP) is introduced to provide an optional mobility management function that can be located at any level in the hierarchy.

When MN moves into an MAP domain and attaches to the access router (AR), the MN obtains a regional care of address (RCoA) from the MAP domain and an local care of address (LCoA) from the AR. Then, the MN sends a BU message to the MAP. This BU message binds the RCoA and the LCoA. The MAP records this BU in its binding cache. The MN also sends the BU messages to its HA and CNs. These BU messages bind the home address of the MN and the RCoA.

The MAP works like a HA since it receives packets addressed to the MN's RCoA from the HA or CNs. Packets are tunneled from the MAP to the MN's LCoA using the IPv6 encapsulation process. The MN decapsulates the packets and processes them in the normal way. As a result, the MN only needs to send BU messages to the HA and CNs when changing the MAP domain. Regional BU (BU to the MAP) is sufficient for an MN within the same MAP domain.

In this way, hierarchical mechanism can improve the performance during the process of handover and reduce the amount of BU messages sent to the HA and CNs [6]. Thus, hierarchical IPv6 mobility management reduces the handover latency and improves the performance of IPv6 mobility management [5].

B. Fast Handover Mechanism

The process of fast handover mechanism for IPv6 mobility management was discussed in [1], [3], [16]. The proposed fast handover mechanism for IPv6 mobility management can reduce packet loss and handover latency [16].

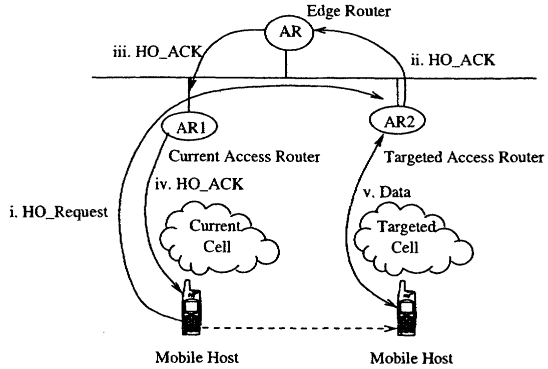

Fig. 2. MN moving from current cell to the targeted cell

Fig. 2 shows the process of fast handover for IPv6 mobility management [16]. The fast handover is performed in the following steps:

i. Handover initiation

When the MN moves from current AR (AR1) to the targeted AR (AR2), MN sends the handover request (HO-REQ) to AR2 via AR1. The request contains the address of AR2 and the demand for bandwidth allocation. AR1 propagates the handover request to AR2. AR2 checks whether the request can be granted.

ii. Handover granted

If the handover request is accepted, AR2 modifies its routing table by inserting a host route for the MN. The request is acknowledged to the MN via the crossover route and the AR1.

iii. New route setup

After AR2 accepts the acknowledgment, AR2 relays the acknowledgment containing the new host route that should be set up in all routers in the wired backbone up to the crossover router. All routers update their routing tables by inserting a host router that goes to AR2 to reflect the new location of the

MN. At this instant, the traffic from hosts behind the edge router can be forwarded to AR2 using the new router.

iv. Old route deletion

The crossover router forwards the acknowledgment to all routers on the old route. The router changes the old route in the routing table. At this instant, the traffic from the previous cell can be forwarded to AR2 using the new route.

Fast handover mechanism improves the performance of IPv6 mobility management because it decreases the time of handover [16]. Shorter handover time has the potential to decrease the packet loss. In the next subsection, we discuss hybrid IPv6 mobility management which is the combination of hierarchical and fast handover mechanisms for IPv6 mobility management.

C. Hybrid IPv6 Mobility Management

The hybrid mechanism has the potential to reduce the effect of handover that induces packet delay in wireless real-time multimedia applications [13]. Howic et al. [11] believe that the hybrid IPv6 mobility management can be the standard of IPv6 mobility management.

The goal of the hybrid IPv6 mobility management is to inform the CN of the new care of address (CoA) immediately after the process of handover. This is accomplished by allowing the AR to send out BUs on behalf of the MN. The BU list in the MN is copied to the AR. This copy must be managed by the AR-proxy in the same way as the original is managed in the MN. The copy is periodically synchronized with the original. As soon as a handover event is detected and the new CoA is generated by the AR, the copy of the BU list is used to inform all the active CNs of the new CoA.

When the MN enters a new domain, it first sends a neighbor advertisement (NA) to the new AR to start the flow of packets over the new wireless link. Immediately following this, a special router solicitation for hybrid proxy message containing the BU list of the MN is sent to the new AR. If the new AR supports the hybrid proxy function, it caches a copy of the current state of the BUs for this particular MN and responds with the hybrid proxy router advertisement. The lack of a response after one retransmission indicates that no hybrid proxy support is available and that basic neighbor discovery must be used.

The MN periodically sends router solicitation for hybrid proxy messages to synchronize the copy of the BU list cached by the new AR with the original. The AR manages the lifetime of the entries in the cached copy in the same way as the MN manages the lifetime of the entries in the original list. This copy of the BU list is used solely for the purpose of sending BUs on behalf of the MN when handover to the new subnet-prefix happens.

Hybrid IPv6 mobility management decreases the handover latency [11]. However, hybrid IPv6 mobility management manages both micromobility and macromobility managements can cause unnecessary load to the mobile Internet [23]. In the next sections, we propose SIP over hybrid IPv6 mobility management and cellular hybrid mobility management to manage micromobility and macromobility managements.

III. SIP over Hybrid IPv6 Mobility Management

A. Session Initiation Protocol

The session initiation protocol (SIP) is an application layer control (signaling) protocol used for establishing and tearing down both unicast and multicast multimedia sessions [10], [25], [8], [17]. It is a lightweight protocol designed to facilitate the transmition of real-time multimedia applications.

Entities in SIP are user agents, proxy servers and redirect servers. Fig. 3 shows a basic procedure of session initiation using SIP [17].

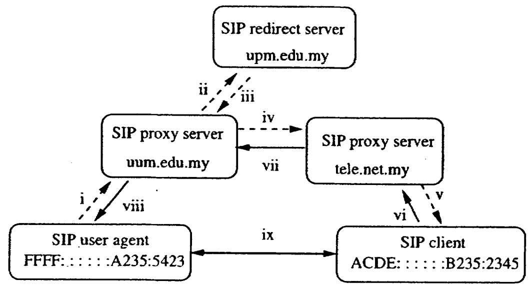

Fig. 3. SIP basic procedure example

In the SIP basic procedure example shown in Fig. 3, a call is initiated by a SIP user agent from FFFF: : : : :A235:5423 to SIP client address ACDE: : : : :B235:2345. The following steps are taken in the SIP basic procedure:

i. The SIP user agent sends an INVITE message to the SIP proxy server using uum.edu.my as the address.

ii. 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 ACDE: : : : :B235:2345 is located.

iii. Because SIP client ACDE: : : : :B235:2345 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 address tele.net.my.

iv. The SIP proxy server uum.edu.my sends an INVITE message to the SIP proxy server address tele.net.my.

v. The tele.net.my server knows the IP address of SIP's client ACDE: : : : :B235:2345 and sends the INVITE message to the host ACDE: : : : :B235:2345.

vi-viii. A SIP response is sent back through redirect/proxy to the SIP user agent FFFF: : : : :A235:5423.

ix. Media is sent directly between SIP user agent and SIP client.

The discussion above presents SIP user agent sends real-time multimedia applications to the SIP client. In the next subsection, we discuss SIP over hybrid IPv6 mobility management where information is transferred in wireless environment. SIP over hybrid IPv6 mobility management is proposed to manage macromobility management when MN performs inter-domain networks handover.

B. SIP over Hybrid IPv6 Mobility Management

As in hybrid IPv6 mobility management, the task of SIP over hybrid IPv6 mobility management is to inform the CN of the new registration immediately after the process of handover. In SIP over hybrid IPv6 mobility management, ARs are designed to send out registrations on behalf of the MN. The registration list in the MN is copied to the AR and this copy is managed by the AR-proxy in the same way as the original is managed in the MN.

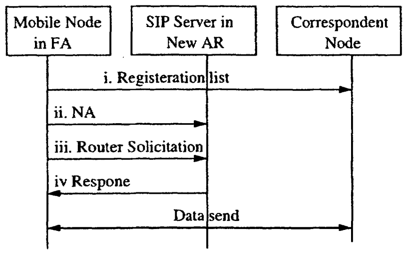

Fig. 4. SIP over hybrid IPv6 mobility management

Fig. 4 shows the steps that are performed as soon as a process of handover is detected in SIP over hybrid IPv6 mobility management environment.

i. A copy of the registration list is used to inform all the active CNs of the new address.

ii. Then, MN sends NA to the SIP server in the new AR.

iii. A special router solicitation for hybrid proxy message containing the registration list of the MN is sent to the SIP server in the new AR.

iv. SIP server in new AR caches a copy of the current registration for this particular MN and responds with a hybrid proxy router advertisement.

v. Then, MN and CN start transmitting real-time multimedia applications.

SIP over hybrid IPv6 mobility management is proposed to manage the process of handover when MN performs inter-domain mobility, namely macromobility management. In the next section, we propose cellular hybrid IPv6 mobility management to manage the process of handover when MN performs intra-domain mobility, namely micromobility management.

IV. Cellular Hybrid IPv6 Mobility Management

A. Cellular IP

Cellular IP is a micromobility management protocol relying on mobile IP for macromobility management [4]. Fig. 5 shows the packet routing mechanism in cellular IP [4]. In cellular IP, a gateway (GW) acts as a mobile IP foreign agent (FA). GW is developed to replace IP inside the wireless access network.

Cellular IP routing mechanism is based on routes established and updated by the MN while connected to the network. All these routes bind the MN while connected to the network and GW. Each station maintains a routing cache that allows it to forward packets from the GW to the MN or vice versa. The routes are established and maintained by the hop-by-hop transmission of a special control packets that trigger the stations on the path to update their routing cache. A BU is periodically sent by the GW and is flooded across the network. This mechanism allows each station to know which one among its interfaces must be used to forward packets towards the GW. The MN sends route update packets when it connects to the network and each time it changes its point of attachment.

The process of handover in cellular IP routing mechanism is managed by two different mechanisms which are hard handover and semi-soft handover [9]. The hard handover provides no guarantees while the semi-soft handover ensures that packet losses will be significantly reduced [9].

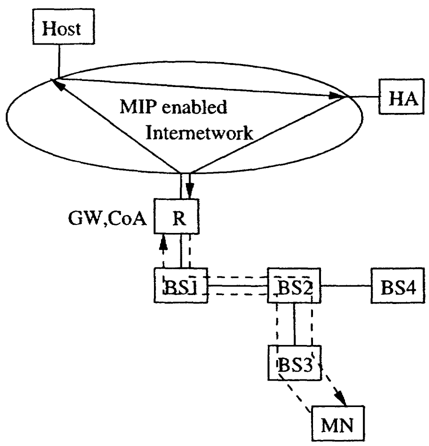

Fig. 5. Cellular IP architecture

When the MN is idle, cellular IP presents a native support for the passive connectivity with a classical paging mechanism [21]. Paging is used to route packets to idle MNs in a cellular IP access network. In paging mechanism, the location management and handover support are integrated with the routing. The advantage of paging is to minimize control messaging, where regular data packets transmitted by MNs are used to refresh MN location information.

Cellular IPv6 mobility management are proposed to manage micromobility management [4], [18]. However, handover latency in cellular IPv6 mobility management may be decreased with the interworking of hybrid mechanism. In the next subsection, we propose cellular hybrid IPv6 mobility management which we believe can decrease the handover latency in micromobility management.

B. Cellular Hybrid IPv6 Mobility Management

The idea of cellular hybrid IPv6 mobility management is to combine the hierarchical and the fast handover mechanisms into cellular IPv6 mobility management. Fast handover mechanism improves handover performance by minimizing the detection time during the process of handover [16]. The neighbor discovery protocol specifies a random router advertisement (RA), which gives the impact detection during the process of handover. By reducing the router advertisement interval, the detection time is reduced and the overall handover latency is reduced [19].

The goal of cellular hybrid IPv6 mobility management is to allocate cellular hybrid IPv6 mobility management to manage intra-domain mobility [6]. During the process of handover within the same hierarchical network, the LCoA changes while the RCoA remains the same. The change of LCoA takes shorter time if compared to the change of RCoA. Intra-domain mobility happens very rapidly. Thus, we propose cellular hybrid IPv6 mobility management to manage intra-domain mobility with ubiquitous MNs.

During inter-domain mobility, both RCoA and LCoA change during the process of handover. The change of RCoA and LCoA take longer time if compared to that of the micromobility. MN needs a longer time to inform HA and CNs when it moves from one AR to another in inter-domain mobility. Thus, the handover process involved in macromobility management has higher impact on the handover latency. We propose that macromobility management is managed by SIP over hybrid IPv6 mobility management.

We believe the proposed cellular hybrid and SIP over hybrid IPv6 mobility management can reduce the signaling load. The reason is because the signaling messages are managed by different mobility managements. Reduce the signaling load has the potential to reduce the handover latency.

Having understood the importance of IPv6 mobility managements in managing micromobility and macromobility, we provide some directions for future research in the next section.

V. Research Direction

Mobile communications are expected to expand rapidly in the near future. The need for continuous networking support and 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.

In this paper, we propose SIP over hybrid and cellular hybrid IPv6 mobility management to manage the macromobility and micromobility. We believe that with these interworking of protocols, the issue of handover latency can be improved.

However, our designed mobility management has less concern on the security treats in wireless communications. Security consideration is an important part of a protocol development. Thus, we propose that in the future, research can be conducted to analyze the security treat in IPv6 mobility management.

VI. Conclusion

In this paper, we discussed IPv6 mobility management. Previous works show that hybrid IPv6 mobility management decreases the handover latency. We propose SIP over hybrid IPv6 mobility management to manage macromobility management. We also proposed cellular IP with hybrid IPv6 mobility management to manage micromobility management. SIP over hybrid and cellular hybrid IPv6 mobility managements may decrease the unnecessary load and handover latency in the mobile Internet. We believe that our propose protocols can provide better communication in the wireless environment.

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