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INTERWORKING OF PROTOCOLS IN IPv6 MOBILITY MANAGEMENT

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***Abstract-* During communication between wireless users, disconnection may occur during the handover process. The high handover latency during the process of handover degrades the service quality of the wireless communications. This problem becomes more crucial if the operation network is transmitting real-time multimedia applications. This paper presents our work on the interworking of protocols in IPv6 mobility management which aims to explore the means to reduce the handover latency. We propose SIP over IPv6 mobility management with hybrid mechanism which we believe has the possibility to reduce the handover latency. The newly proposed protocol is developed and compared with the existing protocols. The result of the simulation experiment shows that our proposed protocol performs better compared to other protocols.**

Index Terms- **IPv6, mobility management, SIP**

I. Introduction

The number of wireless Internet users is expanding in these recent years. Many works have been done which aim to provide better services to the wireless Internet users. One of the motivations is to reduce the handover latency. The reason is because disconnection may occur during the handover process. This problem becomes more crucial if the wireless network is transmitting real-time multimedia applications.

Handley et al. [3] and Schulzrinne et al. [14] have proposed SIP to handle the mobility management when the network is transmitting real-time multimedia applications. SIP is an application layer control protocol used for establishing and tearing down multimedia sessions. The interworking of protocols between IPv6 mobility management and SIP may provide smoother handovers.

Faccin et al. [2] have investigated the issues related to SIP over IPv6 mobility management. They have compared the performance of SIP over IPv4 mobility management and SIP over IPv6 mobility management. SIP over IPv6 mobility management performs better compared to SIP over IPv4 mobility management. The reason is because route optimization mechanism in SIP over IPv6 mobility management can reduce the handover latency. In addition, SIP as the signaling protocol can initiate the multimedia communication. SIP over IPv6 mobility management can reduce the handover latency.

Nakajima et al. [8] have analyzed the duration of delay when MN moves from one network to another in SIP over IPv6 mobility management environment. They have proposed the SIP over IPv6 mobility management testbed with the implementation of intelligent enhanced Linux kernel. The proposed mobility management are analyzed. The results have shown that the SIP over IPv6 mobility management testbed with intelligent enhanced Linux kernel can improve the mobility management performance.

Wedlund and Schulzrinne [15] have discussed mobility support using SIP. They have raised the issue of the triangular routing problem in SIP over IPv4 mobility management. They have proposed SIP over hierarchical IPv6 mobility management, which believe can reduce the handover latency and solve the triangular routing problem.

Having studied the works done by the other researchers, in our work, we aim to interwork the protocols between IPv6 mobility management and SIP with hierarchical and fast handover mechanisms. The combination of hierarchical and fast handover mechanisms with SIP over IPv6 mobility management is proposed. We name the newly proposed protocol as SIP over IPv6 mobility management with hybrid mechanism. We believe that this interworking of protocols decreases the handover latency.

The rest of this paper is organized as follows. Section II presents the SIP architecture. Further in Section III, we discuss the interworking of protocols in SIP over IPv6 mobility management. In Section IV, we present the simulation experiment result and discussion. Section V presents several research directions in this topic. Finally, Section VI concludes this paper.

II. Session initiation protocol (SIP)

SIP is an application layer protocol used for establishing and tearing down multimedia sessions, both unicast and multicast [3], [5], [7], [13]. It is a lightweight protocol designed for the ease in transmitting real-time multimedia applications. Huang et al. [4] had discussed the implementation of SIP in IPv6 mobility management environment. The aim of the implementation is to solve the triangular routing problem. In the following, we present discussion about SIP architecture in IPv6 environment.

A. SIP Architecture

Entities in SIP are user agents, proxy servers and redirect servers. Figure 1 shows a basic procedure of session initiation using SIP.

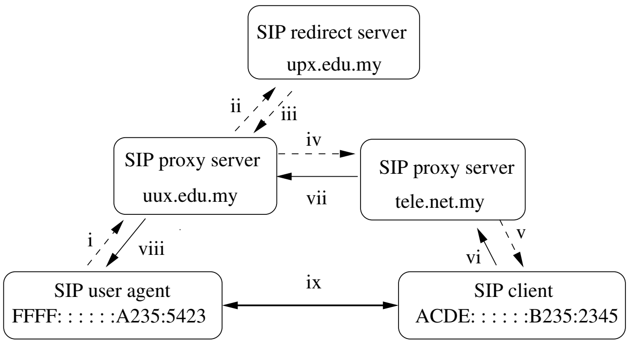

Figure 1: SIP basic procedure example

The example of SIP basic procedure is shown in Figure 1. 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 uux.edu.my as the address.

ii. The SIP proxy server uux.edu.my does a domain name system (DNS) lookup on the SIP redirect server using upx.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 upx.edu.my SIP redirect server, the upx.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 uux.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.

SIP user agent sends real-time multimedia applications to the SIP client in wired and wireless environments. In wireless communication, MN may be static when it connects to the AR with stronger signal strength. MN may move to a location where there is no signal strength, thus disconnection occurs. Another situation is when MN moves from one AR to another AR, which involves a handover process. The duration of packet sends from the sender to the receiver during the process of handover is called the handover latency. Handover latency is an important issue to discuss in order for MN to receive real-time multimedia applications over IP efficiently. In order to provide efficient real-time multimedia applications, researchers study the performance of SIP over IPv6 mobility management, which has been shown to provide a better performance as compared to standard mobile IP.

In SIP over IPv6 mobility management, BU messages are sent to the CNs and HN when MN changes its point of attachment. When the MN is far away from the CNs, sending a BU to the SIP server every time it moves can place an unnecessarily high loads on the SIP server and network, especially if the SIP server is serving many hosts. This may result in high handover latency.

Having known the distortion causes by high handover latency, in the next subsection, we discuss the process of setting up a SIP call and the process involved during mid-call SIP mobility in a wireless environment.

B. Setting Up a SIP Call

Setting up a SIP call ensures that the CN can send real-time multimedia applications to the MN [14]. Figure 2 shows the process of setting up a SIP call. When CN intends to communicate with the MN, the following steps are taken.

i. The CN sends an INVITE request to the SIP server in HA.

ii. SIP server in HA notifies MN's new contact address to CN.

iii. CN then sends an INVITE request to MN in FA directly.

iv. MN receives the INVITE request and sends a 200 OK message to the CN.

v. CN sends data to MN and communication starts.

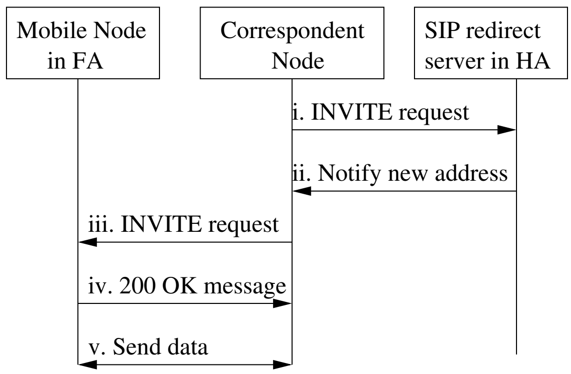

Figure 2: Setting up a call

C. Mid-call SIP Mobility

During real-time multimedia communication between MN and CN, MN may move from one AR to another. Here, we discuss the process involved during mid-call SIP mobility, which is performed when MN moves from one AR to another during the communication of real-time multimedia applications. MN needs to inform CN on the changes of IP addresses. Figure 3 shows the process involved during mid-call SIP mobility. Mid-call SIP mobility allows a node to continue an ongoing session with its peer during the handover process. The following steps are taken.

i. MN in FA sends a re-INVITE request with a new IP address to CN.

ii. CN directly sends data to MN at the new point of attachment in the network.

iii. MN receives the data and continues the communication with CN.

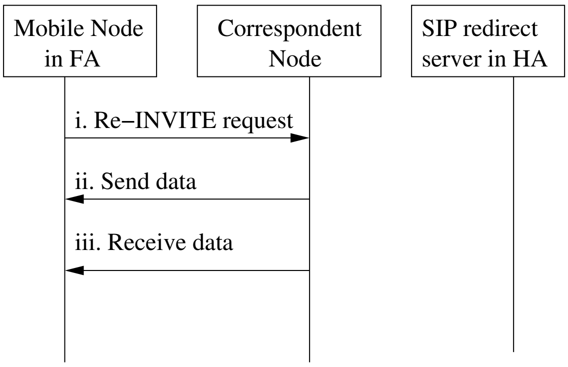

Figure 3: Mid-call SIP mobility

As discussed in previous section, previous works have proposed SIP over IPv6 mobility management to handle the mobility management. In the next section, we present the interworking of protocols in SIP over IPv6 mobility management.

III. Interworking of Protocols in SIP over IPv6 Mobility Management

In this paper, the interworking of protocols refer to the interworking of protocols between SIP over IPv6 mobility management with hierarchical and IPv6 mobility management with fast handover mechanisms. In addition, we propose the interworking of protocols between SIP over IPv6 mobility management with hierarchical and fast handover mechanisms which we name it as SIP over IPv6 mobility management with hybrid mechanism. These three interworking of protocols are discussed in detail in the following subsections.

A. SIP over IPv6 Mobility Management with Hierarchical Mechanism

In SIP over IPv6 mobility management, BU messages are sent to HA and CN when MN changes the point of attachment. MN sends a BU to the SIP server every time it moves, which places an unnecessarily high loads on the SIP server and network, especially if the SIP server is serving many hosts. This may cause higher handover latency.

Instead, the MN can register with a closer SIP server. The SIP server on the CN knows to which SIP server it should redirect the incoming request. This shortens the time of registration and thus decreases the handover latency.

Figure 4 shows the process of SIP servers in hierarchical path. The following steps are taken.

i. CN sends the INVITE message to the SIP redirect server.

ii. The SIP redirect server sends the current MN's address to CN.

iii. CN then sends SIP INVITE message to the SIP proxy server.

iv. The SIP proxy server then sends the INVITE message to MN in the FN.

v. After receiving the INVITE message, MN sends the SIP OK response message back to the SIP proxy server.

vi. The SIP proxy server then sends the SIP OK response message back to the CN.

vii. CN starts sending data to MN and further communication continues.

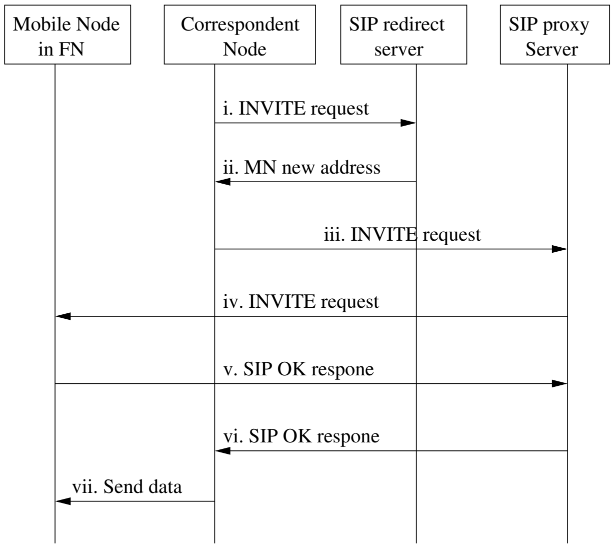

Figure 4: SIP over IPv6 mobility management with hierarchical mechanism

SIP over IPv6 mobility management with hierarchical mechanism reduces handover latency [2]. In the next subsection, we discuss another mechanism that reduces the handover latency namely SIP over IPv6 mobility management with fast handover mechanism.

B. SIP over IPv6 mobility Management with Fast Handover Mechanism

The idea of SIP over IPv6 mobility management with fast handover mechanism is to interwork SIP as an lightweight protocol with fast handover mechanism in IPv6 mobility management environment [9]. Figure 5 shows the steps on SIP over IPv6 mobility management with fast handover mechanism.

The first step is the handover detection where the MN initiates a handover process. As the MN moves from one domain to another domain, the AR of the previous network detects the need to handover to another network as the signal strength of the previous network becomes weaker.

The MN in the FN sends out handover initiation to the adjacent ARs. This handover initiation contains information about the possible new ARs. Thus, the AR knows which new point of attachment of the MN. Once the AR obtains the information of the new AR, the new CoA is generated. This CoA is sent to MN and becomes the new IP address of MN. The autoconfiguration is accomplished according to the IPv6 mobility management which reduces the handover delay.

As a SIP client, the MN needs to establish a new connection to the new AR. Thus, MN registers its new IP address with the SIP server of the new domain. The MN sends re-INVITE request to SIP proxy of the new AR. The proxy relays this request to CN and establishes a connection. The CN acknowledges to MN with a 200 OK and establishes call set up. Once call setup has been established, packets are sent between the MN and CN with real-time multimedia applications.

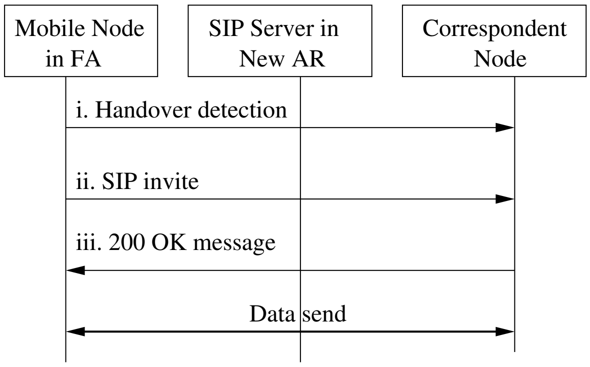

Figure 5: SIP over IPv6 mobility management with fast handover mechanism

Another operation that may reduce handover latency is SIP over IPv6 mobility management with hybrid mechanism, which is the process of combining both hierarchical mechanism and fast handover mechanism in SIP over IPv6 mobility management. SIP over IPv6 mobility management with hybrid mechanism has the potential to reduce the impact of handover that induces packet delay in wireless real-time multimedia applications. The next section discusses the process involved during the process of handover in SIP over IPv6 mobility management with hybrid mechanism.

C. SIP over IPv6 Mobility Management with Hybrid Mechanism

The goal of SIP over IPv6 mobility management with hybrid mechanism is to inform the CN of the new registration immediately after handover during transmission of real-time multimedia applications [10], [12]. This is accomplished by allowing the AR to send out registrations on behalf of the MN. Figure 6 shows the SIP over IPv6 mobility management with hybrid mechanism steps. 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.

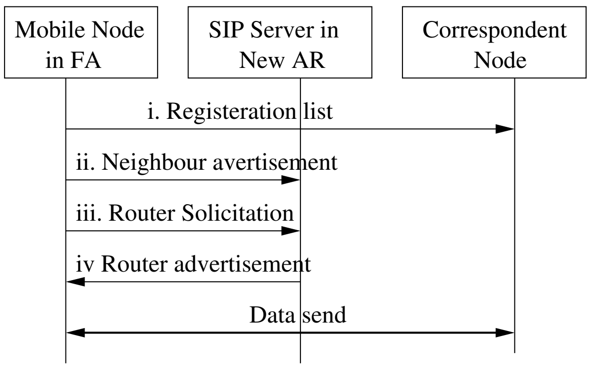

Figure 6: SIP over IPv6 mobility management with hybrid mechanism

Figure 6 shows the steps that are performed as soon as a process of handover is detected in SIP over 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 a neighbour advertisement (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 IPv6 mobility management with hybrid mechanism is proposed to handle the process of handover when MN is transmitting real-time multimedia applications. The session initiation in SIP reduces the handover latency. In the next section, we present the simulation experiment and the discussion on the simulation experiment result.

IV. SIMULATION RESULT AND DISCUSSION

We use simulation technique to evaluate the performance of SIP over IPv6 mobility management. In particular, the aim of the simulation experiment is to find out the latency when the MN performs the process of handover. We use network simulator namely ns-2 to evaluate the performance. The detail discussion of the experiment setup can be referred to [11].

Table 1 presents the result of the simulation experiment. As shown in Table 1, in over all, SIP over IPv6 mobility management with hybrid mechanism performs better compared to SIP over IPv6 mobility management with fast handover and SIP over IPv6 mobility management with hierarchical mechanisms.

As an example, for the packet size of 1000 bytes, we observe that SIP over IPv6 mobility management with fast handover mechanism has the handover latency of 1.090s. Whereas, SIP over IPv6 mobility management with hierarchical mechanism has the handover latency of 0.965s. Additionally, SIP over IPv6 mobility management with hybrid mechanism performs better than the other two mechanisms which has the handover latency of 0.965s.

	Handover Latency (s)		
Packet Size (bytes)	SIP over Fast Handover	SIP over Hierarchical	SIP over Hybrid
250	0.524	0.519	0.495
500	0.676	0.664	0.635
750	0.864	0.845	0.819
1000	1.090	0.965	0.956
1250	1.215	1.079	1.068
1500	1.396	1.097	1.087

Table 1: Handover latency of SIP over IPv6 mobility management mechanisms

We plot the result of the simulation experiment in Table 1 into a graph in Figure 7. From Figure 7, we observe that as the packet size increases, the handover latency increases. The reason is because as the size of packet increases, the network needs more time to transmit the packet [6]. Again, from Figure 7, we conclude that our proposed protocol, namely SIP over

IPv6 mobility management with hybrid mechanism performs better compared to the other two mechanisms.

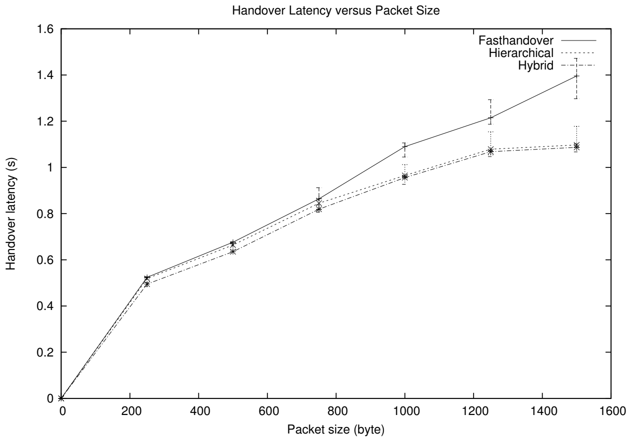

Figure 7: SIP over IPv6 mobility management handover latency

Table 2 presents the result of the simulation experiment for the throughput efficiency for all the three SIP over IPv6 mobility management mechanisms. The throughput efficiency is calculated by the total of throughput gained divided by the maximum possible throughput (The maximum possible throughput is 100%). From Table 2, we observe that there is no significant improvement in term of throughput efficiency for SIP over IPv6 mobility management with hybrid mechanism. Since the real-time multimedia applications are loss tolerant, throughput efficiency has less effect on the communication network.

Throughput Efficiency (%)

Packet Size (bytes)	SIP over Fast Handover	SIP over Hierarchical	SIP over Hybrid
250	89.9	88.8	88.9
500	97.0	94.6	94.6
750	98.9	95.5	95.7
1000	99.1	95.9	96.0
1250	99.7	96.1	96.2
1500	1.00	96.2	96.4

Table 2: Throughput Efficiency of SIP over IPv6 mobility management mechanisms

We plot the result of the simulation experiment in Table 2 into a graph in Figure 8. From Figure 8, we observe that as the packet size increases, the throughput efficiency increases. The reason is because by sending the same amount of data with smaller packet size, more packet overheads are sent over the IP. Whereas, we observe that the throughput efficiency is higher for higher packet sizes.

However from Figure 8, we observe that the throughput efficiency for the three SIP over IPv6 mobility management mechanisms are quite similar. There are no significant improvement for the three SIP over IPv6 mobility management mechanisms. Since SIP over IPv6 mobility management mechanisms are proposed to transmit the real-time multimedia applications, throughput efficiency is not the main concern of evaluation.

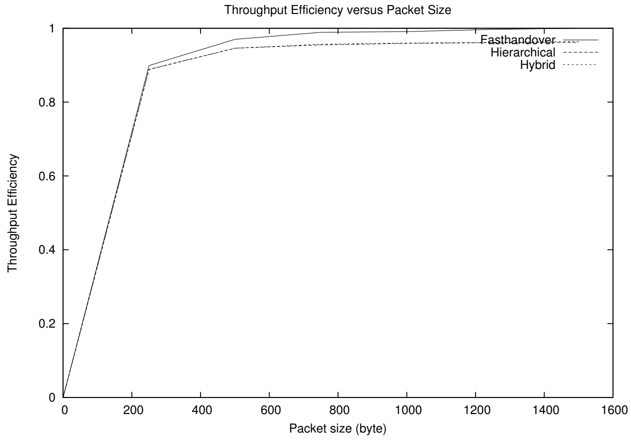

Figure 8: SIP over IPv6 mobility management mechanisms throughput efficiency

From the simulation experiment result, we conclude that our proposed protocol, namely SIP over IPv6 mobility management, reduces the handover latency. This proposed protocol provides better communication to users. However, there are some other fields that need further research. In the next section, we present some of the research directions.

V. Research Directions

The work reported in this paper opens the way for continued research in a number of directions. A particularly interesting area for future research is implementing the proposed protocol in the real mobile and wireless Internet network. We propose that before implementing the developed protocol in the real mobile and wireless Internet network, a SIP over IPv6 mobility management testbed is developed. This reduces the possibility of failure in the real Internet.

Wireless communication always relates to some security issues since attacks can happen in several ways [1]. In this paper, we had proposed few new protocols where during the development we have ignore the security issues. Thus, in the future, research can be conducted to study the effects of these newly proposed protocols in term of security study.

VI. Conclusion

In this paper, we discussed the interworking of protocols in IPv6 mobility management. We propose the interworking of SIP over IPv6 mobility management with hybrid mechanism. The simulation result shows that our proposed protocol decreases the handover latency. These proposed protocols can provide better communication in the wireless environment.

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