# Improving of Terminal-Independent Handover Method with SIP Mobility

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***Abstract*** - With the development of mobile communication technology in public wireless LAN, handover technologies become more important. The purpose of this study is to improve the communication performance of the terminal-independent handover method, and to achieve handover between different types of network. We propose the method to implement the expanded SIP Mobility to wireless LAN routers, and the method to shorten the acquisition time of the IP address by dynamically changing the transmission timing of the router. And we evaluate these proposed methods by the simulation experiments.

***Keywords***: Handover, SIP, Wireless LAN.

## 1 INTRODUCTION

Recently, IPv4 addresses hare in danger of depletion, and the use of IPv6 addresses is promoted. However, the incompatibility between IPv4 and IPv6 has prevented the wide use of IPv6 address. IPv6 shift test [1] is carried out on a global scale in 2011, and it is expected that use environment of the IPv6 is regulated well.

There are also significant developments in the use of public wireless LAN and mobile terminals such as note PCs and smart phones. Therefore, the opportunities for communicating terminal to change communicating wireless LAN router by its movement are expected to increase. However, in the current public wireless LAN environment when a communicating mobile terminal moves over multiple domain of different wireless LAN router, the IP address of the mobile terminal changes. When an IP address is changed, the TCP which is transport protocol cannot maintain the connection, and disconnection of communication is occurred. Therefore, the importance of handover techniques which keep communication when the mobile terminals move between wireless LAN routers has been increasing. There are some researches of handover techniques such as a PMIPv6 (Proxy Mobile IPv6) [2] and the method using a SIP (Session Initiation Protocol) Mobility method [3, 4].

The PMIPv6 is one of the terminal-independent handover methods. This technology is consisted of the LMA (Local Mobility Anchor) and the default routers. The LMA is the position management server of the mobile terminals. The PMIPv6 switches over the communication path between the LMA and the default routers during the handover of the mobile terminal. Therefore, even mobile terminals can use the PMIPv6 without the need for any special features. However, communication passes is through the LMA. As a result, the LMA is predisposed toward bottleneck when the number of communicating mobile terminals on the increase.

SIP runs sessions establishing, changing, and cutting between terminals. The SIP Mobility is session changing. Terminals can have a communication path of choice after SIP session consisting. Therefore, communication is insulated from the influence of bottlenecks. SIP Mobility enables handovers when it is implemented in the mobile terminals. However, every mobile terminal cannot run a handover with this method because it presupposes implementation to the mobile terminal.

We propose a handover method that uses SIP Mobility expansion. This method involves introducing the SIP mobility expansion into the ingress router. The router can establish and change the SIP session. The communication does not pass through a specific server, and the mobile terminal can use this technology without the need to have any special feature. However, the number of mobile terminals becomes depleted by a handover because the mobile terminals that take this IP address are long. We focused on the RA (Router Advertisement) packet, which is sent by a wireless LAN router. The RA packet assigns IP addresses to the mobile terminal. We propose dynamically changing the sending timing of the RA packet and thus reducing the amount of time needed for the mobile terminal to receive IP addresses and thus improve communication and present the evaluation result of the simulation.

## 2 RELATED TECHNOLOGY

This chapter is an overview of the PMIPv6 and the SIP Mobility.

### 2.1 PMIPv6

The PMIPv6 is a terminal-independent handover method in which the mobile terminal runs a handover without the need for any special features and can hold the TCP connection. This technology consists of the LMA and the default router. It constructs a tunnel between the LMA and the default router, and the terminal's communication path is controlled. IPv6 consists of a Network Prefix and Link Local Address. The Network Prefix is a network identifier, and terminals are assigned this by the network. The Link Local Address is derived from the MAC address of terminals. The LMA keeps tabs on the Network Prefix and identifier of the mobile terminal, and the mobile terminal assigns the same Network Prefix to the LMA after a handover. Therefore, the mobile terminal can keep up the same IP address even though it runs a handover. However, the mobile terminal cannot run a handover between MAGs that connect other LMA. Therefore, the mobile terminal can use the PMIPv6 only if the mobile terminal runs a handover between MAGs that have the same connection as the LMA. The processing of the PMIPv6 is shown in Figure 1.

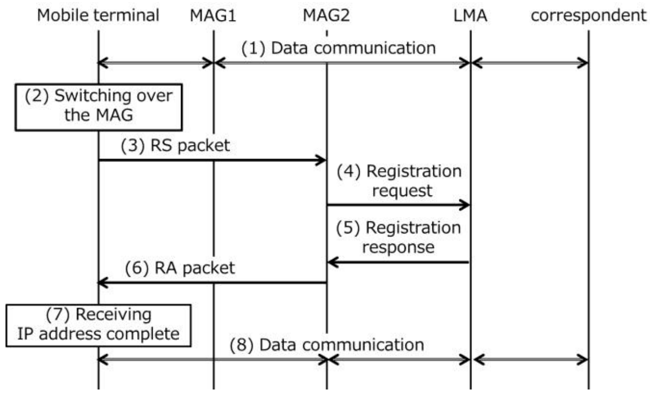


Figure 1: Processing of PMIPv6 handover

This process premises on connecting the mobile terminal to the MAG 1, and the mobile terminal communicates to a correspondent. A tunnel is constructed between the LMA and the MAG 1, and data communication is run by way of the LMA (Figure 1 (1)). The mobile terminal sends a RS (Router Solicitation) packet to the MAG 2 when it switches over to MAG (Figure 1 (2) - (3)). A RS packet is a required of a RA packet. The MAG 2 sends the information of the mobile terminal to the LMA when the MAG 2 receives the RS packet (Figure 1 (4)). The LMA updates the information of the mobile terminal, and it sends an acknowledgement to the MAG 2 (Figure 1 (5)). The MAG 2 constructs the LMA and sends the RA packet to the mobile terminal (Figure 1 (6) – (7)). The mobile terminal resumes communication and completes a handover (Figure 1(8)).

The mobile terminal communicates by way of the LMA with the PMIPv6 and uses the PMIPv6 without the need for any special features because a tunnel switches over between the LMA and MAGs.

## 2.2 SIP Mobility

The SIP is a session initiation protocol and runs a SIP session establishing, changing, and cutting between more than one terminal. The SIP Mobility is the SIP session changing. The SIP can establish a SIP session that only terminal handles and the SIP message is sent and received by way of the SIP server. After establishing the SIP session, mobile terminals can communicate without the SIP server. The mobile terminal describes the IP address that gives out the destination wireless LAN router to the SIP message, and re-establishes the SIP session with a correspondent, and is able to switch over to communication path. The processing of the SIP Mobility is shown in Figure 2.

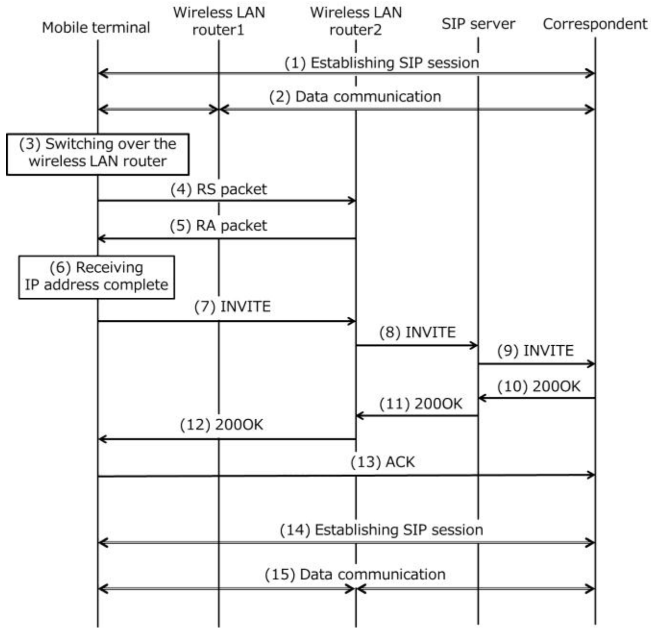


Figure 2: Processing of SIP Mobility handover

This process premises on connecting the mobile terminal to wireless LAN router 1, and the mobile terminal and correspondent handle the SIP (Figure 2 (1)). They establish the SIP session and communicate data (Figure 2 (2)). The mobile terminal sends a RS packet to wireless LAN router 2 when it switches over to wireless LAN routers, and wireless LAN router 2 sends a RA packet to the mobile terminal (Figure 2 (4) – (5)). The mobile terminal acquires the IP address after receiving the RA packet (Figure2 (6)). The mobile terminal sends this IP address to the correspondent and re-establishes the SIP session (Figure 2 (7) – (14)). Then, they restart data communication (Figure 2 (15)).

The mobile terminal can maintain data communication because it re-establishes the SIP session. A portion of the terminal converges into a load because data communication is done by way of SIP server.

## 2.3 Tasks

There are five problems with the existing method

i. Bottleneck-prone

The PMIPv6 impedes data communication because this technology gets centered on data communication to the LMA, where bottlenecks tend to occur.

ii. Technology not available in a different network

The mobile terminal cannot run a handover with the PMIPv6 in a different network because this technology can only be used between MAGs connecting the same LMA.

iii. Unsustainable TCP connection

The mobile terminal cannot run a handover as the TCP connection is unsustainable with the SIP Mobility because the mobile terminal changes the IP address.

iv. Need for specific features for the mobile terminal
The SIP Mobility must be implemented in the mobile terminal.

v. Disconnection for an amount of time during handover
The PMIPv6 and the SIP Mobility take long to get the IP address, disconnect for an amount of time, and proceed with communication after a handover with the mobile terminal because they do not implement any specific features to the mobile terminal. As a result, we thought they impede communication performance.

## 3 PROPOSED METHOD

This chapter is an overview of the proposed method. Details on the system are given in our past research [5]. Therefore we expound shortening the time of taking IP address because we are not expound research past of ours.

### 3.1 Overview

In this study, we purpose a terminal-independent handover method in which the mobile terminal uses a handover technology without the need for any special features and accepts a handover in a different network. The SIP Mobility no longer needs to be the communication path by way of SIP server. We focus on the SIP Mobility for problems i, ii, iii, and iv in Section 2.3. Routers are implemented in the SIP, which establishes and changes the SIP session between routers and supports the handover of a mobile terminal. Therefore, the mobile terminal uses our proposed method without the need for any special features. This method can run a handover in a different network by setting up a SIP server in internet. Only one SIP cannot maintain the IP address of the mobile terminal. Therefore, wireless LAN routers give out the same Network Prefix for all mobile terminals. The mobile terminal does not change the IP address even if it connects to every wireless LAN route, and it can maintain TCP connection. We call this method using expanded SIP Mobility method.

We explain problem v of Section 2.3. The most part of disconnection time during a handover is said to be the time spent receiving a RA packet to the mobile terminal after finishing off the L2HO (Layer 2 handover) and the time spent on DAD (Duplicate Address Detection) [6]. We measured the time between disconnection and reconnection to wireless LAN routers for the mobile terminal, and this time was determined to be about 3.8 seconds. The time spent for DAD was about 1 second. Therefore, the mobile terminal took over 2 seconds to receiving the RA packet. Therefore, we propose improving the communication performance by means of shortening the time spent on taking the IP address.

### 3.2 Prerequisite

The proposal deals with the possibility of the IPv6 network. An example of the network configuration is shown in Figure 3.

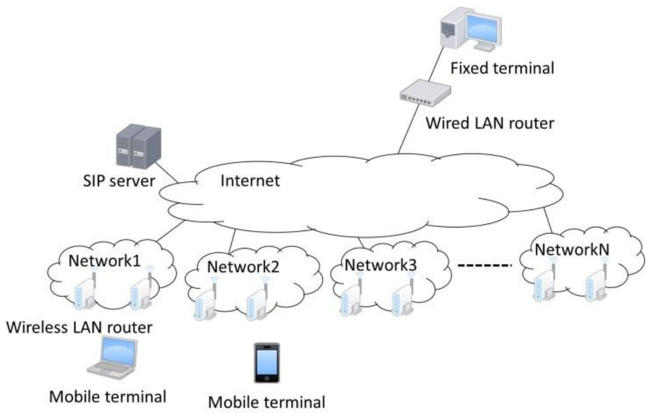


Figure 3: Network configuration example

The mobile terminal moves between network1 and network N, and this network is a different ISP.

### 3.1 Using expanded SIP Mobility method

A handover method that uses SIP Mobility expansion is a terminal-independent handover method. This method is a SIP to introduce and add function for a handover to the default routers of terminals. The SIP Mobility expansion has function of sending the identifier from the mobile terminal to the SIP server, sends passage of the mobile terminal to other routers, and establishes SIP session between routers. This method expands the SIP server to have the information that manages the mobile terminals. This information is connecting wireless LAN routers and correspondents in the mobile terminal, thus expanding the functions of routers to giving out the same Network Prefix for all mobile terminals, running encapsulation and decapsulation for packets and the detection of the passage of mobile terminals, and taking the information from the SIP server.

When the mobile terminal communicates, routers establish the SIP session between routers and runs encapsulation for the packets of the mobile terminal. The mobile terminal can maintain communication after a handover because the destination wireless LAN router changes the SIP session. The process for using expanded SIP Mobility method is shown in Figure 4.

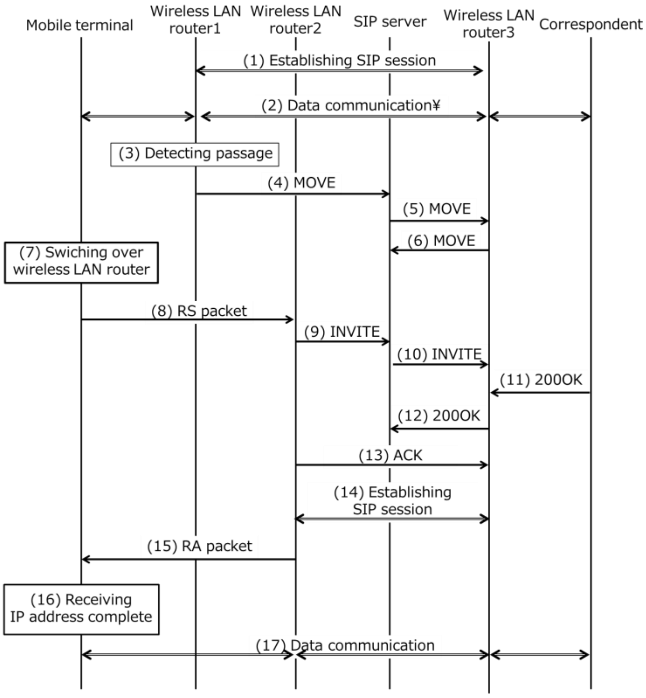


Figure 4: Processing of using expanded SIP Mobility method handover

This process premises on connecting the mobile terminal to the wireless LAN router1, and the mobile terminal is communicating to a correspondent. Wireless LAN routers monitors the RSSI (Received Signal Strength Indication) and it sizes up the movement of the mobile terminal. A SIP session is established between wireless LAN router 1 and wireless LAN router 2, and data communication is run between the mobile terminal and correspondent (Figure 4 (1) – (2)). Wireless LAN router 1 sends the MOVE message to other wireless LAN routers by way of the SIP server when the RSSI drops to a lower value by moving the mobile terminal (Figure 4 (3) – (6)). The MOVE message is the identifier of the mobile terminal and the information. Wireless LAN routers that receive this message keep up a definite period of time. The mobile terminal sends a RA packet to wireless LAN router 2 when it switches over to wireless LAN router 2 (Figure 4 (8)). Wireless LAN router 2, which receives this message, makes a comparison between the identifier of the mobile terminals with the MOVE message and the information. If it agrees with the identifier of the mobile terminals, wireless LAN router 2 establishes the SIP session with the information (Figure 4 (9) – (14)). Wireless LAN router 2 sends a RA packet to the mobile terminal after a definite period of time (Figure 4 (15)). The mobile terminal that receives this packet acquires IP address and proceeds with communication (Figure 4 (16) – (17)).

The SIP message goes through SIP server, but data communication is not needed for the SIP server. Therefore this method uses communication path of choice. In addition, the mobile terminal can use this method without the need for any special features because switching over to the communication path is run between wireless LAN routers. This method accepts a handover in a different network because SIP server exists on the internet.

## 3.2 Shortening the time spent taking IP addresses

Then we expound shortening the time spent taking IP address. The processing of the current mobile terminal handover is shown in Figure 5.

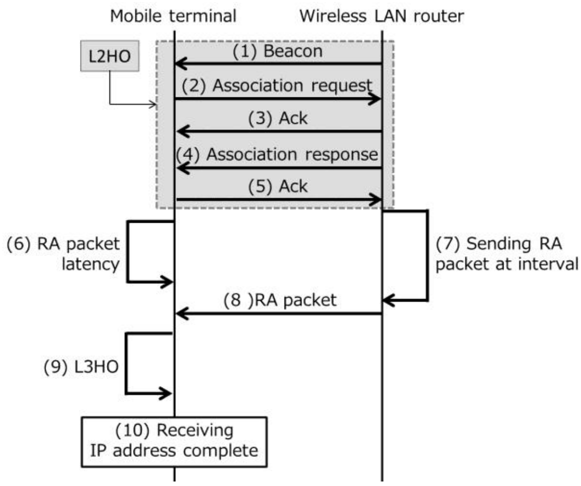


Figure 5: Processing of present mobile terminal handover

The general wireless LAN router broadcasts the Beacon that it passes on the SSID to the mobile terminal (Figure 5 (1)). The mobile terminal that receives the Beacon starts the L2HO and establishes the Association to the wireless LAN router (Figure 5 (2) – (5)). The mobile terminal stands ready to receive the RA packet after the completion of L2HO (Figure 5 (6)). The transmission interval of RA packet is regular, and the setting range of this interval is between 3 and 1800 seconds. The wireless LAN router sends a RA packet to the mobile terminal after a definite period of time, and the mobile terminal runs the L3HO (Layer 3 handover) and gets the IP address (Figure 5 (7) – (10)). If the mobile terminal does not receive the RA packet for a long time, it sends a RS packet to the wireless LAN router 2. Therefore, the handover of the mobile terminal takes over 2seconds after finishing the L2HO because it comes no later than the starting of the L3HO.

The proposal reduces delay that wireless LAN routers send the RA packet to the mobile terminal as soon as the L2HO. The processing of the proposed handover is shown in Figure 6.

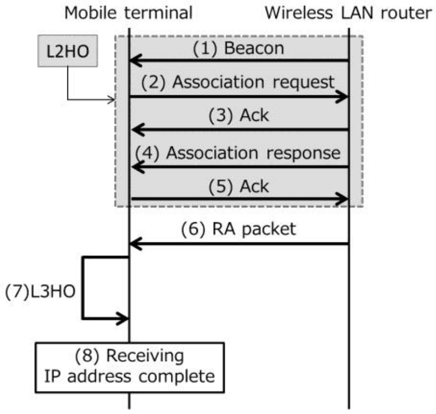

Figure 6: Processing of proposed handover

The L2HO runs conventionally (Figure 6 (1) – (5)). Layer 3 of the wireless LAN router monitors layer 2. The wireless LAN router sends a RA packet to the mobile terminal after receiving the Ack of the Association response (Figure 6 (6)). The delay does not occur between finishing the L2HO and starting L3HO, as the mobile terminal receives the RA packet the L2HO is finished, and the mobile terminal acquires the IP address (Figure 6 (7) – (8)). Therefore, the mobile terminal is shorter than the current mobile terminal, so it proceeds with communication early.

# 4 EXPERIMENTATION AND EVALUATION

In this chapter, we explain our evaluation. We evaluated the proposed method with the NS2 (Network Simulator version 2) [7] and by running and not running a handover of throughput and the number of packet drops. As a target for comparison is the PMIPv6.

## 4.1 Comparative evaluation

This section is a comparative evaluation of the PMIPv6 and proposed method. This comparative evaluation is shown in Table 1.

Table 1: Comparative evaluation

| | PMIPv6 | Proposed method |
|---|---|---|
| Bottleneck | Easy to generate | Hard to generate |
| Running a handover between different networks | Impossible | Possible |
| Time taking IP address | Long | Short |

First, we explain the bottleneck. The PMIPv6 easily converges into a load at the LMA because the mobile terminal runs communication by way of the LMA. The proposed method easily generates a bottleneck because the mobile terminal runs communication without the need for a specific server.

Second, we explain a handover between different networks. The mobile terminal cannot use the PMIPv6 between different networks because it can only run a handover between MAGs connected with the same LMA. The proposed method can establish a SIP session even if the mobile terminal runs a handover between different networks because the SIP server is put on the internet. Therefore the proposed method can be used between different networks.

Finally, we explain the time spent taking IP addresses. PMIPv6 is an amount of time spent taking IP address as in Section 3.2 because it assumes common mobile terminals. The proposed method can take IP address to quickly because wireless LAN routers send a RA packet to the mobile terminal immediately after L2HO by using the mobile terminals. Therefore, the proposed method shortens the time spent taking IP address.

## 4.2 Experimentation description

In this section, we explain experimentation environment and simulation parameters. We used version ns-2.27 of NS2, and this simulator was run on the Ubuntu-9.04. An evaluation of proposal topology is shown in Figure 7, the evaluation of PMIPv6 topology is shown in Figure 8, and the simulation parameters are shown in Table 2.

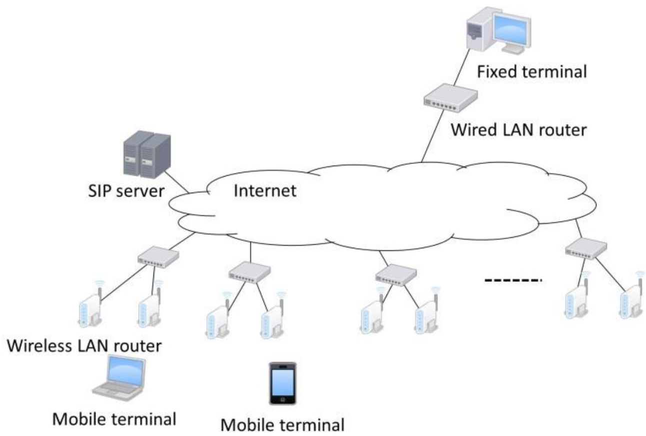

Figure 7: proposed method topology

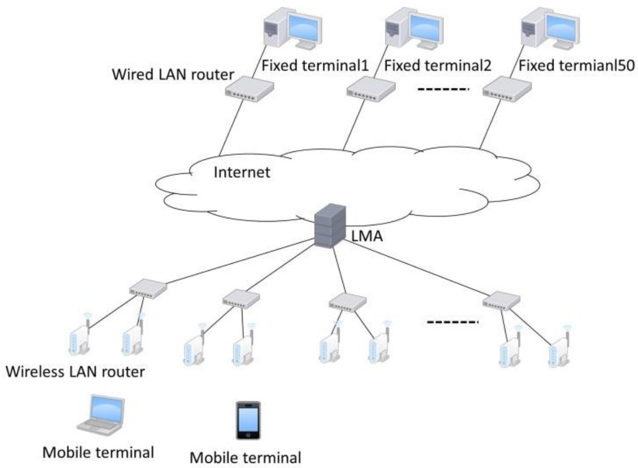

Figure 8: PMIPv6 topology

Table 2: Simulation parameters

| | |
|---|---|
| Transmission speed of wireless LAN routers (Mbps) | 54 |
| Bandwidth (Mbps) | 100 |
| Simulation time (sec) | 500 |
| Traffic | FTP |
| Packet size (byte) | 1000 |
| Delay the internet (ms) | 40 |
| Delay except the internet (ms) | 10 |
| Number of wireless LAN routers (routers) | 50 |
| Number of fixed terminal (terminals) | 50 |

We referred to references [8] what the topology of PMIPv6 and set the topology of proposed method similar to the topology of PMIPv6.

We assumed a wireless LAN standard of IEEE802.11n, and set the bandwidth that does not become bottleneck. The application protocol is FTP because we assumed the file transfer. We send ping to yahoo.co.jp, determined RTT and set delay the internet with this RTT. Delay except the internet is set lower values than delay the internet because physical distance of except the internet is shorter than the internet.

The communication direction was from a fixed terminal to a mobile terminal. These terminals are one-to-many. The mobile terminal connects the wireless LAN routers. These are one-to-one or one-to-two.

## 4.3 Evaluation results and examination

This section shows the results and the examination of running and not running a handover. We experimented on several TCP congestion control algorithms. Evaluated TCP congestion control algorithms are Tahoe, New Reno and Vegas. This section shows only Tahoe because there is little difference in these TCP congestion control algorithms.

### 4.3.1. Not running a handover

The average throughput for 500 seconds is shown in Figure 9, and the number of packet drops is shown in Table 2.

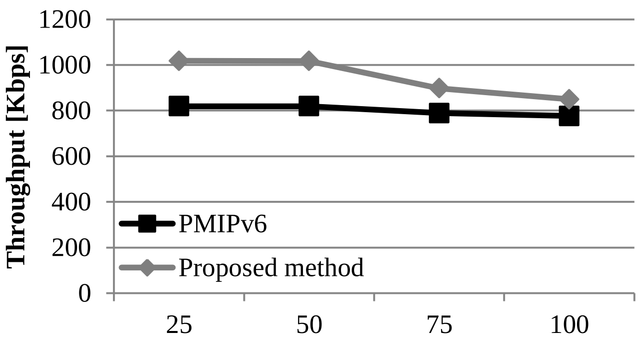


Figure 9: Average throughput for 500 seconds

Table 3: Number of packet drops

| Number of Mobile terminal (terminals) | | 25 | 50 | 75 | 100 |
|---|---|---|---|---|---|
| Proposal (packets) | | 16 | 25 | 330 | 913 |
| PMIPv6 (packets) | All | 0 | 0 | 222 | 609 |
| | LMA | 0 | 0 | 192 | 602 |

For 25 and 50 mobile terminals, the proposed method obtained 1.25 times higher throughput did The PMIPv6. The proposed method did not generate bottlenecks easily because the mobile terminal ran communication without the need for a specific server. However the proposed method had a much higher number of packet drops than did PMIPv6. The proposed method overflowed the queue that connected routers with fixed terminals. This queue overflow is thought to be caused by TCP window size becoming large by communicating without the need for a specific server, and the router's queue reached the maximum number of packets that can be stored. For 75 and 100 mobile terminals, the throughput of the proposed method dropped to a lower value. It is thought that queue overflow occurred often due to the increase in the number of communicating mobile terminals. The queue overflow did not occur due to the one router that connected the fixed terminals. This overflow occurred routers that connected fixed terminals. The most packet drops for PMIPv6 occurred at the LMA. These drops occurred due to converging packets to the LMA. Therefore, it is thought that the communication performance of PMIPv6 deteriorated due to the increase the number of communicating mobile terminals. In the case where a low number of mobile terminals communicated with the same fixed terminal, the communication performance of the proposed method did not get worse but rather improved more than did PMIPv6.

### 4.3.2. Running a handover

Each mobile terminal ran five handovers in 500 seconds. The average throughput for 500 seconds is shown in Figure 10.

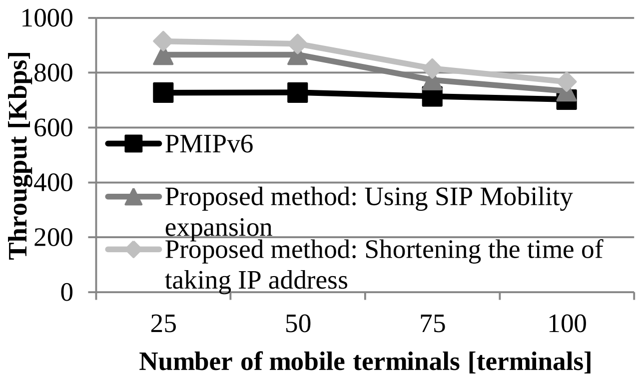


Figure 10: Average throughput for 500 seconds

The proposed method improved the throughput by shortening the time spent taking the IP address because the mobile terminal could run communication quickly after a handover. The throughput of PMIPv6 and the proposed method is nearly equal with the increasing number of mobile terminals. It can be said that this is said the same as not running a handover. Therefore, the communication performance of the proposed method improved.

## 5 CONCLUSION

In this study, we purposed a terminal-independent handover method in which the mobile terminal uses a handover technology without the need for any special features and accepted a handover in a different network. We proposed using expanded SIP Mobility method and shortening the time spent taking IP addresses. We experimented with and evaluated the method with a simulator. PMIPv6 impeded on the communication of mobile terminals by going through the LMA. Using expanded SIP Mobility method limited the influence on communication performance by not going through a specific server. The current mobile terminal caused a delay between the completed L2HO and the starting L3HO. Shortening the time spent taking IP addresses cut down on delays by sending RA packet immediately after the completion of the L2HO.We evaluated PMIPv6 and the proposed method. A comparative evaluation showed the effectiveness of the proposed method in that it is rarely generates bottleneck, runs a handover between different networks and shortens the time spent taking IP addresses. Experimentation showed the improvement in the communication performance of the proposed method from using expanded SIP Mobility method and the shortening of the time spent taking IP addresses.

In the future, we will consider evaluating massive topology to show the effectiveness of the proposed method.

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