Implementation of Mobile PPC Realizing Mobility of Mobile Nodes

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Abstract

We have proposed a new communication system called Mobile PPC (Mobile Peer to Peer Communication), which can keep their connections during their communications even though they change their locations, without using any extra devices. We have implemented Mobile PPC in IP layer, and evaluated the system.

1. Introduction

In recent years, the number of users who carries a mobile node such as a note PC or a PDA, and connects it to the Internet at any places has been increasing. In these circumstances, a system that does not affect communications between a mobile node and the Internet even though the mobile node changes its locations during the communications has been requested. In TCP/IP, since an IP address contains location information of the node, a different IP address is assigned if the mobile node changes its location. As transport layer of the node regards that the communication is different if the IP address is different, the communication breaks if the node changes its location.

Thus, various kinds of technologies realizing "mobility", that is, keeping communications when the node moves, have been researched [1]. Mobility technologies can be roughly classified into two approaches, those are Proxy approach and End-to-End approach. Mobile IP [2] is the delegate of Proxy approach. In Mobile IP, Home Agent (HA) which manages locations of mobile nodes is introduced as a proxy server. Packets from a correspondent node (CN) to a mobile node (MN) are received by HA, who knows the location of MN, and then relayed to MN using tunneling technology. Packets from MN to CN are directly transferred without HA. Though Mobile IP is a fine technology, there are some problems, namely, it requires extra devices such as HA, there is redundancy of the communication path, and extra header is needed while the tunnel transmission. In Mobile IPv6 (Mobile IP for IPv6) [3], route optimization function is introduced, and the problem of redundancy of the communication path has been resolved. However, HA is still needed, as the communication has to begin via HA at the first stage. LIN6 [4] is the delegate of End-to-End approach. In LIN6, an IP address is divided into two parts, namely, a node identifier and a location indicator, and Mapping Agent (MA) is introduced to manage the relationship between the node identifier and the IP address. LIN6 can conceal the IP address changes from upper layer software, however, as LIN6 applies the shrink address model of IPv6, address space is largely degraded, and global-unique allocation of IP addresses is needed. Further, in LIN6, MA is needed as an extra device. Also LIN6 is not applicable to IPv4.

The authors have been proposed a new mobility technology called Mobile PPC (Mobile Peer to Peer Communication). Mobile PPC is a kind of End-to-End approach and is realized in IP layer. Also it does not need any extra devices. In Mobile PPC, an address change function is introduced in the IP layer of both end nodes. When the IP address is changed in MN, the information is reported from MN to CN, and an address change table is made in both nodes. From then, IP addresses in communication packets are changed according to the table. By this method, the change of the IP address is concealed from the upper layer software. We have implemented Mobile PPC and confirmed the function. In this paper, results of evaluation of Mobile PPC are reported.

2. Outline of Mobile PPC

In order to realize mobility, a method of getting an initial IP address of a partner when communication starts (referred to as an initial IP address resolution) and a method of getting a new IP address when MN

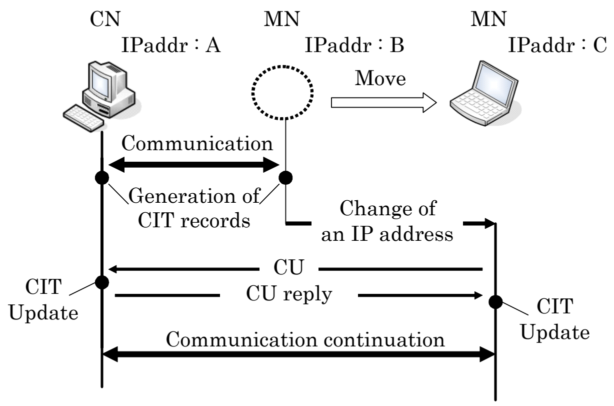

Fig. 1. A new address report

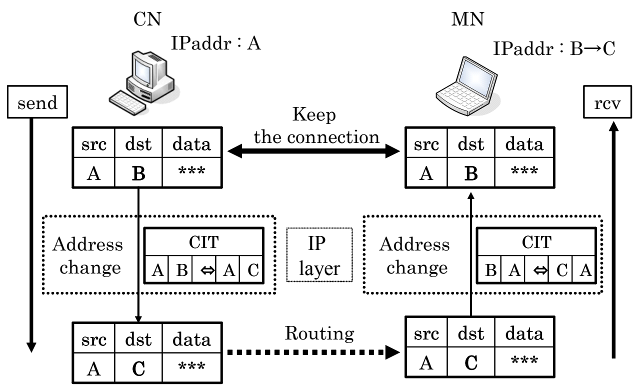

Fig. 2. Procedure for IP address changes

moves (referred to as a continuous IP address resolution) must be realized. For the initial IP address resolution, a technology of dynamic DNS (hereinafter, DDNS) [5-6] which dynamically manages the relationship between a host name and an IP address can be used. DDNS is already in practical use. For the continuous IP address resolution, Mobile PPC (Mobile Peer to Peer Communication), which is the main theme in this paper, is used.

Mobile PPC consists of a new address report function, and an IP address change function. The end node holds Connection Identifier Table (hereinafter, referred to as CIT) which shows the relationship of an IP address before movement and an IP address after movement per a connection identifier. The connection identifier is information that identifies a communication, and consists of a pair of end IP addresses, a pair of port numbers, and a protocol number. A CIT record is generated when a communication begins and is renewed every time when MN moves. The IP address change is executed on every sending and receiving packets referring the contents of CIT.

Table. 1. Modules and functions realizing Mobile PPC

Module	Function
Address change	Address change according to the contents of CIT and re-calculation of checksum.
Move control	CU negotiation
CIT operation	Reference, generation, and renewal of CIT.
CIT deletion	Deletion of a CIT record when there is no communication.

Fig. 1 shows the sequence of a new address report. If MN is moved to another network during the communication with CN, MN acquires a new IP address from DHCP server at the destination. MN generates CIT UPDATE (CU) packet which includes the new IP address and the connection identifier, and sends it to CN. CN updates CIT of its own based on information reported by CU. CN sends back CU reply packet to MN, and MN updates its own CIT. After the CU negotiation, IP addresses of the communication packets are changed in the IP layer according to the CIT records. Address changes are executed only after the MN movement. Newly started communications use the IP address of MN acquired at that location, and address changes are not executed at the initial phase.

Fig. 2 shows procedure for IP address changes when the IP address of MN is changed from B to C. The destination IP address of the packet from CN to MN is changed from B to C according to CIT in CN, and reversed from C to B according to CIT in MN. Similar address changes are executed in the case of an opposite side.

As described above, the address change is executed in IP layer so that the packet is correctly routed, and the change of IP address is concealed to higher layer software. Thus, it is possible to keep the connection even if an IP address changes during the communication.

3. Implementation method of Mobile PPC

3.1. Module configuration

As for a target OS, we have chosen FreeBSD because there are plenty of documents describing information of IP layer. Table.1 shows modules and their functions realizing Mobile PPC. Address change module, Move control module and CIT operation module, and CIT deletion module are incorporated in the IP layer.

Mobile PPC software is called from ip_input which

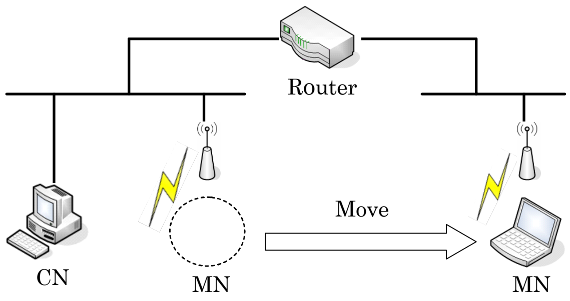

Fig. 3. A trial system environment

Table. 2. Device specifications

	MN	CN
CPU	Celeron 2 GHz	Pentium 2.4GHz
Memory	256 MB	256 MB
NIC	IEEE802.11b	100BASE-T

is the IP input function when the packet is received, and called from ip_output which is the IP output function when the packet is transmitted. Other parts of OS are not changed at all.

3.2. CIT

CIT has 2,048 records, and each record consists of an initial connection identifier at the beginning of the communication, IP addresses and port numbers after the movement, cancellation counter, and next CIT address.

CIT is implemented as a hash table, and the retrieval key is the hash value of the connection identifier. A chain method is used for hash retrieval algorithm, and in the case of a collision of a hash value, the next CIT address is used for the next link.

The cancellation counter is periodically decremented by a CIT deletion daemon. The value is initialized when the record is retrieved. When the value becomes 0, it is judged that there are no communications between the nodes, and the record is deleted.

3.3. CU

CU (CIT UPDATE) is defined on the basis of ICMP Echo Request, and MN generates and sends CU for CN when MN gets a new IP address at the destination. The data part of ICMP includes the new IP address and the initial connection identifier, which can be plural.

4. Evaluation of Mobile PPC

Table. 3. Acquiring time of a new IP address

	Acquiring time of the new IP address
Maximum	9.01 [sec]
Average	6.33 [sec]
Minimum	4.11 [sec]

※10 times trial

Table. 4. A renewal time of CIT

The number of connections of the End node	1	2	3	4
Average time [msec]	4.61	4.57	4.72	5.16

※Average of 10 times

Table. 5. Processing time for every 1 packet

Existence of address translation	The address change is not performed	The address change is performed
Average time [μsec]	1.04	1.57

4.1. Confirmation of mobility

Mobility of Mobile PPC has been confirmed by a trial system shown in Fig. 3. Table. 2 shows the specification of the devices of MN and CN.

While FTP file is continuously transferred from MN to CN, MN is moved to another network. After MN has acquired a new IP address from DHCP server, it has been confirmed that the FTP communications continues with Mobile PPC functions in CN and MN.

4.2. Measurement of processing time

(1) Communication breaking time

When MN is moved to another network, there occurs communication break until communication resumes. This time is the sum of an acquiring time of the new IP address from DHCP server, and a renewal time of CIT. Table. 3 shows the acquiring time of the new IP address, and Table. 4 shows the renewal time of CIT per existing connection numbers at the time, respectively. The renewal time of CIT includes CIT changing time in MN and CN, and CU packet transmission time. While the renewal time of CIT is 4~5milliseconds, the new IP address acquiring time is 6.33 seconds on the average. Thus, it is seen that most of the communication breaking time is the IP address acquiring time.

(2) Processing time per packet

We have measured extra processing time of packet execution when Mobile PPC is implemented. Table. 5

Table 6. Download time using FTP

Mobile PPC	Not implemented	Implemented	
Address change	—	NO	YES
Average time [sec]	17.4024	17.4918	17.5463

shows the extra processing time per a packet when in the case MN is in original place (with no address change) and in the case after the movement (with address change). Averages of the processing time for every 100 packets are measured and Pentium Time Stamp Counter is used. From Table. 5, it is seen that the time required for Mobile PPC is about 0.5 microseconds and it is seen that influence to performance is little.

(3) Performance measurement using FTP

We have measured the degradation of the performance using FTP when Mobile PPC is implemented.

Table. 6 shows the comparison of download time when 10M files are down-loaded from MN to CN using FTP in a case 1; in which Mobile PPC is not implemented, in a case 2; in which Mobile PPC is implemented and with no address change (before movement), and in a case 3; in which Mobile PPC is implemented and with address change (after movement). When the case 1 is taken as the reference, the processing time is increased by 0.5% in the case 2, and by 0.8% in the case 3.

From these findings, it is concluded that the overhead by Mobile PPC is less influential in a practical use.

5. Conclusion

The communication system Mobile PPC that realizes mobility is proposed. We have implemented Mobile PPC in IPv4, and it is confirmed that mobility works fairly well and that there are almost no degradations in performance.

In future, we will study the method that minimize the break time of the communication when MN moves, and study the application of Mobile PPC to IPv6.

References

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Background

- Numbers of users are going to carry mobile nodes.
- Wireless network environment has been increasing.

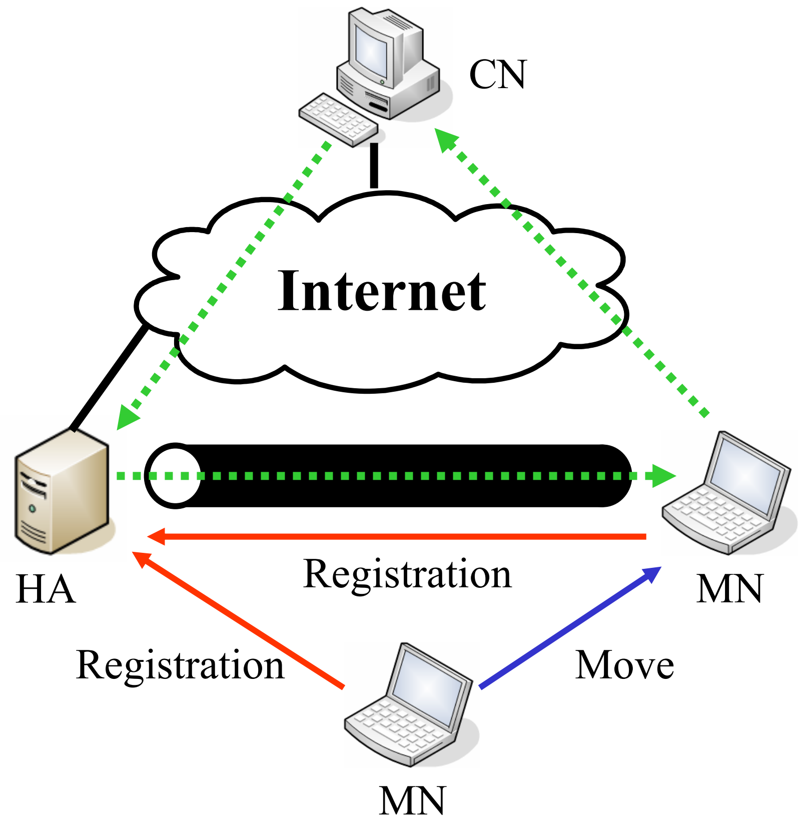
  ⇒A system that can keep communications even though mobile nodes change their locations has been requested.
- In TCP/IP
  - A different IP address is assigned when the mobile node changes its location.
  - Transport layer of the node regards that the communication is different, if the IP address is different.

  ⇒The communication breaks if the node changes its location.

“mobility” is very important in the Internet

Mobile IP

- An existing technology and its problems
  - Mobile IP
    - It requires an extra device such as HA (Home Agent)
    - There is redundancy of the communication path.
    - An extra header is needed during the tunnel transmission.



We have been proposing Mobile PPC
(Mobile Peer to Peer Communication)

Mobile PPC (Mobile Peer to Peer Communication)

- In order to realize mobility in the Internet
  - An initial IP address resolution
    - A method of getting an initial IP address at the beginning the communication.
  - A continuous IP address resolution
    - A method of getting a new IP address when MN moves.

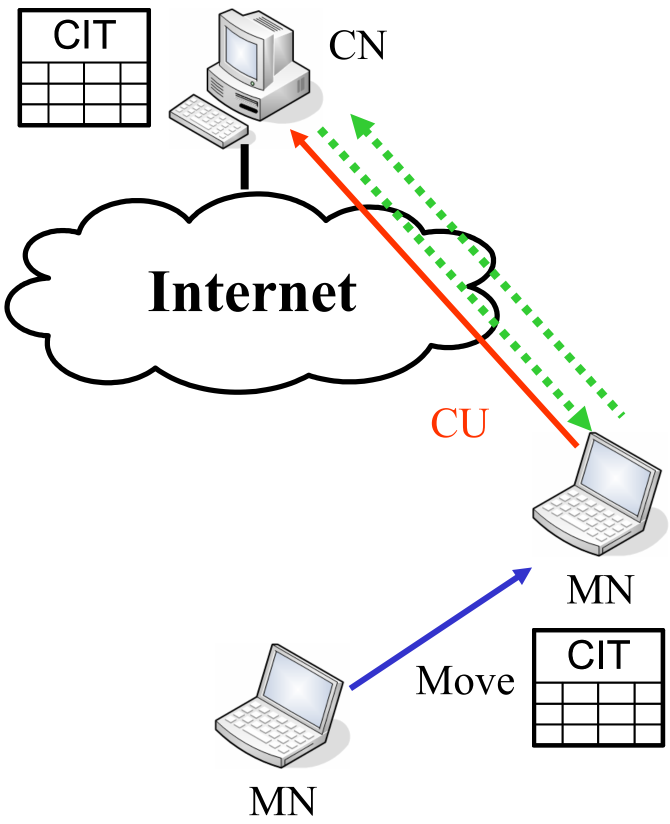
  ⇒These two functions are Separated clearly.

➢ The initial IP address resolution
DDNS (dynamic DNS)
  - DDNS dynamically manages the relationship between a host name and an IP address.
  - DDNS is already in a practical use.

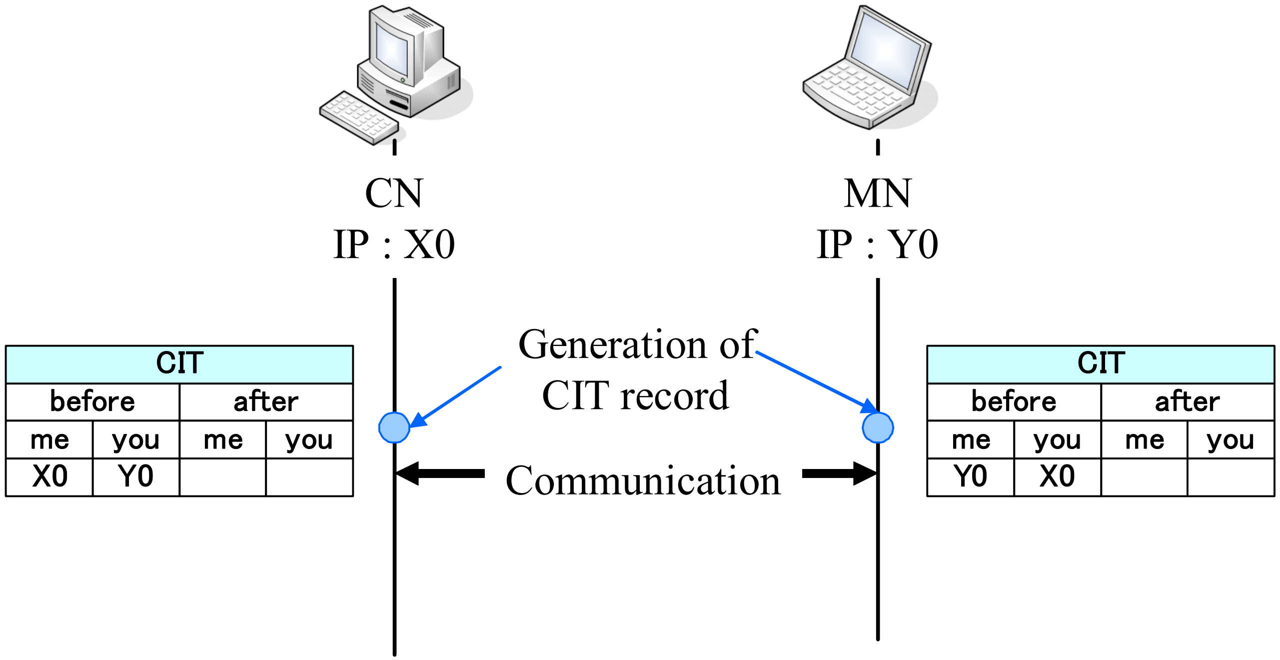
➢ The continuous IP address resolution
Mobile PPC (Mobile Peer to Peer Communication)

Mobile PPC

- Summary
  - Each end node holds CIT (Connection ID Table)
    - CIT indicates the relationship between an IP address before movement and an IP address after movement.
  - Following functions are executed in each end node in IP layer.
    - ✓ **A new address report function.**
      - MN and CN exchange the new IP address with CIT Update packets called CU and CU reply to maintain the CIT records.
    - ✓ **An IP address change function.**
      - IP address changes are executed on every sending and receiving packets referring the CIT records.



The sequence of new address report

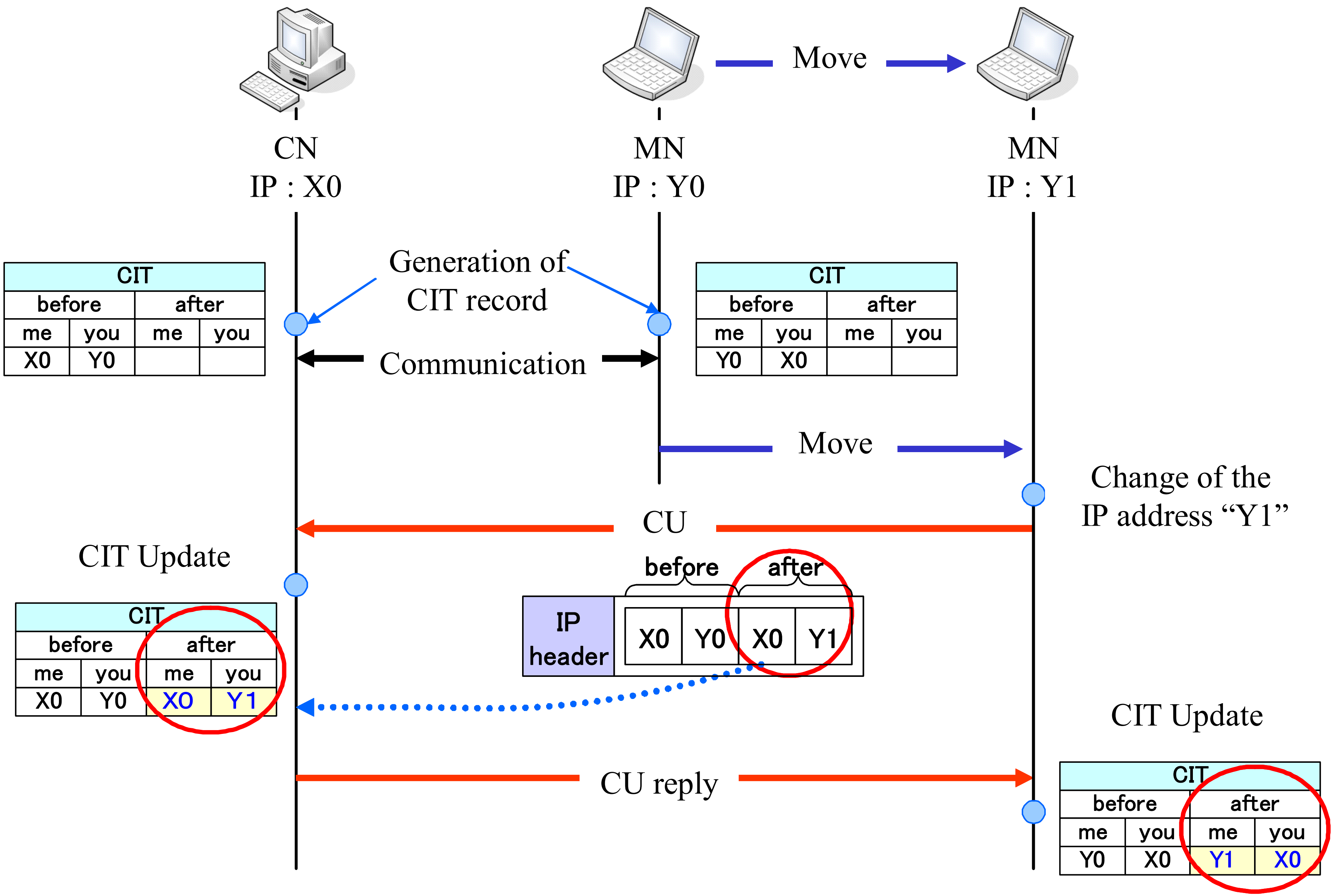


CIT			
before		after	
me	you	me	you
X0	Y0		

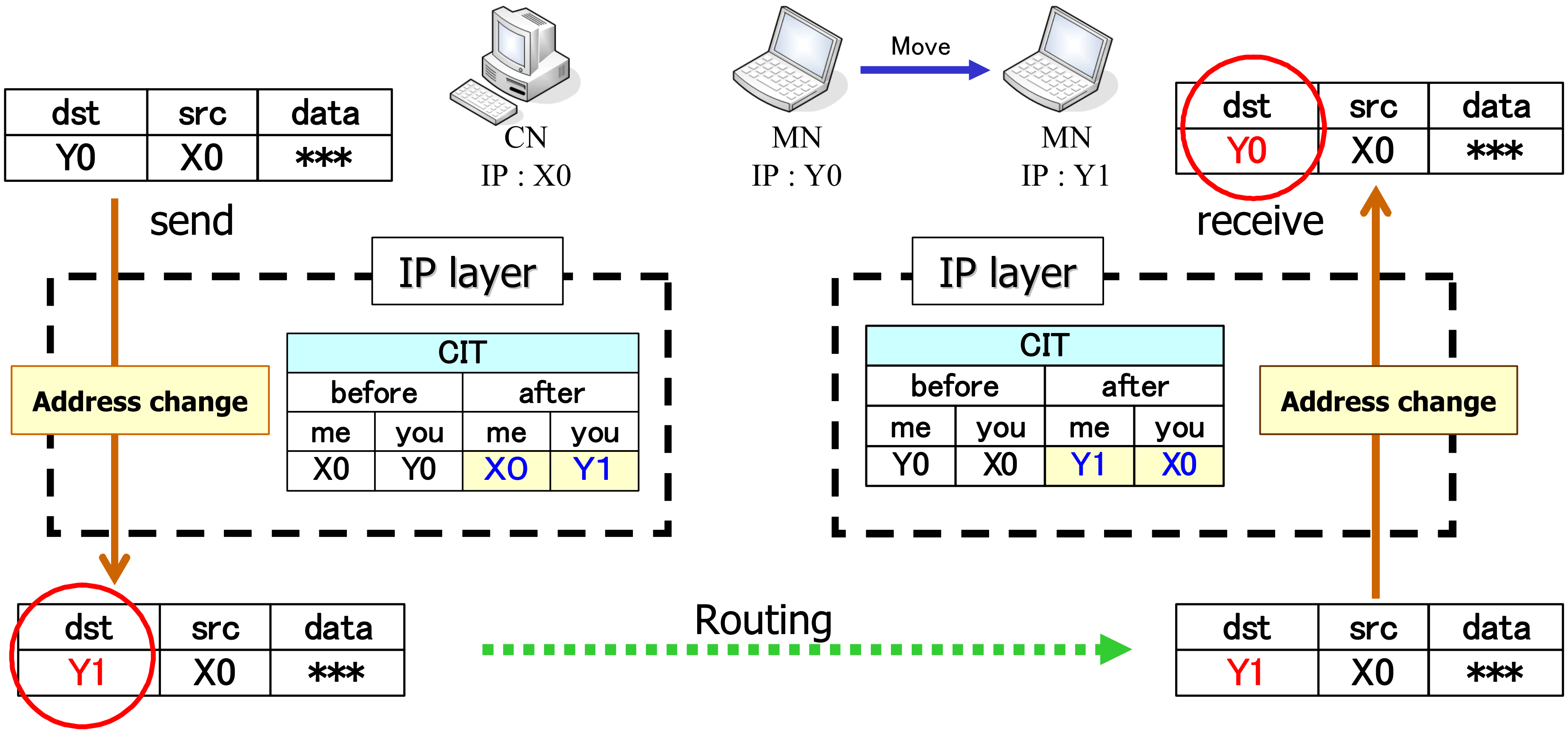
- Before — IP Addresses before movement
- After — IP Addresses after movement
- Me — IP Address of its own
- You — IP Address of communication partner

- The CIT record is generated when a communication begins.
  - At the beginning, the CIT's "after" field is vacant.

The sequence of new address report



The procedure of IP address change



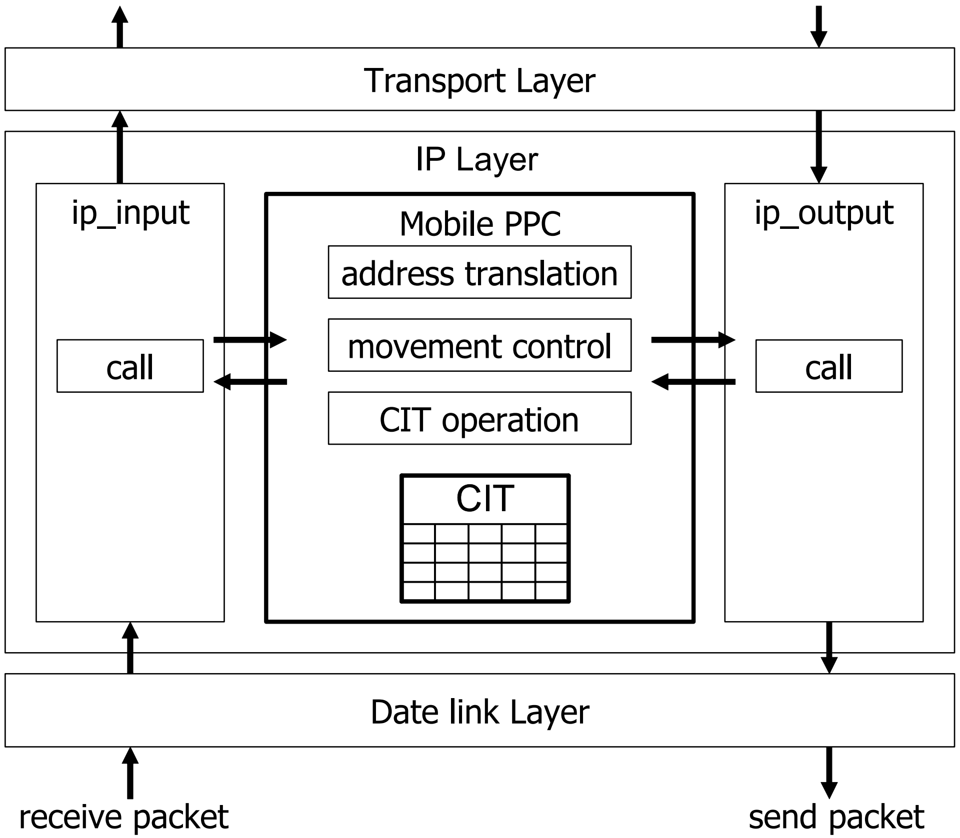
- The destination IP address of the packet from CN to MN is changed from "Y0" to "Y1" according to the CIT record in CN.
  ⇒The packet is correctly routed.
- The packet is reversed from "Y1" to "Y0" according to the CIT record in MN.

Mobile PPC

- The address changes are executed in an IP layer.
  - The packets are correctly routed.
  - The change of IP address is concealed to higher layer software.
- Advantage of Mobile PPC
  - Mobile PPC does not need any extra devices like HA in Mobile IP.
  - There is no redundancy in the communication path.

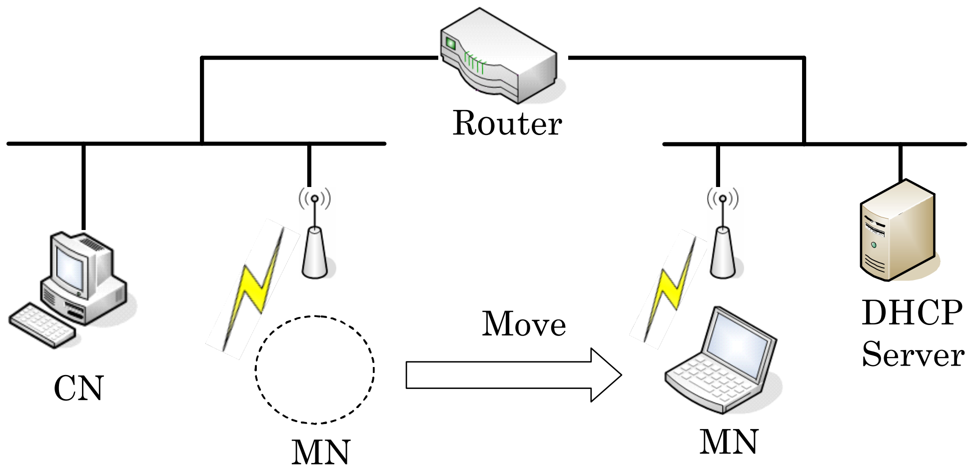
Implementation

- Mobile PPC modules are implemented in the kernel of FreeBSD(5.2.1-R).
- Mobile PPC module is simply called from ip_input() and ip_output(), and returned after the process completes.
- It does not affect the existing process in the IP layer.



A trial system

- Mobile PPC is installed in MN and CN.
  - First, FTP file transmission is started from MN to CN, then MN moves to the other network during the transmission.
  - MN first acquires a new IP address from a DHCP server, then Mobile PPC begins, namely, the new address report, and the address change.



	MN	CN
CPU	Celeron 2GHz	Pentium 2.4GHz
Memory	256M	256M
NIC	IEEE802.11b	100BASE-T

We have confirmed that the FTP transmission continues

Communication breaking time

- Communication breaking time is sum of ① and ②.
  - ① An acquiring time of the new IP address from DHCP server.

Minimum	Average	Maximum
4.11 [sec]	6.33 [sec]	9.01 [sec]

  - ② A renewal time of CIT
    - CIT renewal in MN and CN
    - Packet transmission time of CU and CU reply
      - ➢ 4.61×10^{-3} [sec]

⇒The most of the communication breaking time is the IP address acquiring time.

Performance measurement

- The degradation of performance

Table: The comparison of download time when 50MB files are down-loaded from MN to CN using FTP.

Mobile PPC	Download time
①Not Implemented	87.31[sec]
②Not Address Change	87.31[sec]
③Address Change	87.40[sec]

①Mobile PPC is not implemented in MN and CN.

②Mobile PPC is implemented in MN and CN, and address changes are not executed, namely before the movement of MN

③Mobile PPC is implemented in MN and CN and address changes are executed, namely after the movement of MN

Performance measurement

- The degradation of performance

Table: The comparison of download time when 50MB files are down-loaded from MN to CN using FTP.

Mobile PPC	Download time
①Not Implemented	87.31[sec]
②Not Address Change	87.31[sec]
③Address Change	87.40[sec]

- A measurement result
  - ① and ② takes just the same time, that shows there is no degradation with Mobile PPC.
  - ③ shows the degradation of about only 0.1%.
  - ⇒ There is almost no degradation in communication.

Conclusion and Future Works

- Mobile PPC can realize mobility without any extra devices
  - We have implemented Mobile PPC in IPv4.
  - It is confirmed that mobility works fairly well.
  - There is almost no degradation in performance.
- In future
  - We are going to apply Mobile PPC in Windows OS.
  - We are studying how to apply the technology into IPv6.