Proposal of a packet-lossless handover in Mobile PPC

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***Abstract*-On the mobile computing environment where countless mobile terminals are connected to the Internet for communications, it is strongly demanded that communication is maintained even when mobile terminals change their locations. However, in TCP/IP, IP addresses change along with the movement of terminals, and communication is inevitably broken. To solve this problem, we have been studying a new technology called "Mobile PPC" that can achieve "mobility" only with end terminals. Although Mobile PPC has resolved the problem, packet loss is unavoidable when the terminal moves. Moreover, when two end terminals move simultaneously during the communication, the communication breaks in Mobile PPC. In this paper, we propose a new technology to realize a packet-lossless handover in Mobile PPC taking measures both in a link layer and the function of Mobile PPC in end terminals.**

I. INTRODUCTION

In recent years, the number of users who carry mobile terminals such as note PCs or PDAs, and connects them to the Internet, wherever and whenever they desire, has been increasing. In this situation, a system that does not affect communications between mobile terminals and the Internet even when the mobile terminals change their location during communication has been eagerly looked for. In TCP/IP, as an IP address contains location information of the terminal, a different IP address is assigned when the mobile terminal changes its location. Because the transport layer software of the terminal regards that the communication is a different one if the IP address is different, the communication is to break when the terminal changes its location. Thus, various kinds of technologies to realize "mobility", that is, to maintain communications even when the terminal moves, have been researched [1].

Mobility technologies can be roughly classified into two approaches; namely, one is called "Proxy approach" and the other is called "End-to-End approach". Mobile IPv4 [2] for IPv4 is a representative form of the Proxy approach. Though Mobile IP is a fine technology, it has some problems. For example, it requires extra devices such as Home Agent (HA). Its communication path is redundant. And an extra header is required during the tunnel transmission. The authors have been proposing a new mobility technology called "Mobile PPC" (Mobile Peer to Peer Communication) [3], which is a type of the End-to-End approach. It does not require any extra device, and mobility functions are realized in the IP layer in end terminals.

These technologies support mobility functions fairly well, although, packet loss or the occurrence of short communication interruption is inevitable at the time of movement. The reason is that the handover function in the data link layer (L2) and the IP layer (L3) are in general executed independently, when an end terminal moves. L2 handover and L3 handover are defined separately, and there exists no coordination between the two. As L3 handover starts after the completion of L2 handover, there is unavoidably a time they cannot communicate with each other, and communication packets are lost during this time.

In addition, in case of the End-to-End approach, such as Mobile PPC, if both end terminals move simultaneously during communication, there occur a serious problem that the communication after movement is broken because they mutually send packets to old IP addresses.

In this paper, we propose a new technology realizing a packet-lossless handover in Mobile PPC to solve the problem shown above, by taking measures in both L2 and L3 functions.

II. HANDOVER IN MOBILE PPC

A. *Summary of Mobile PPC*

Mobile PPC is a protocol that can realize mobility only with end terminals without being supported by a third device. In a Mobile PPC system, Mobility operations are clearly separated into two functions; one is the function to detect the IP address of a correspondent terminal at the beginning of communication (that is called "Initial IP address resolution"), and the other is the function to keep the communication while the terminal is moving during communication (that is called "Continuous IP address resolution"). For the Initial IP address resolution, a technology of dynamic DNS (DDNS) [4] which dynamically manages the relationship between the host

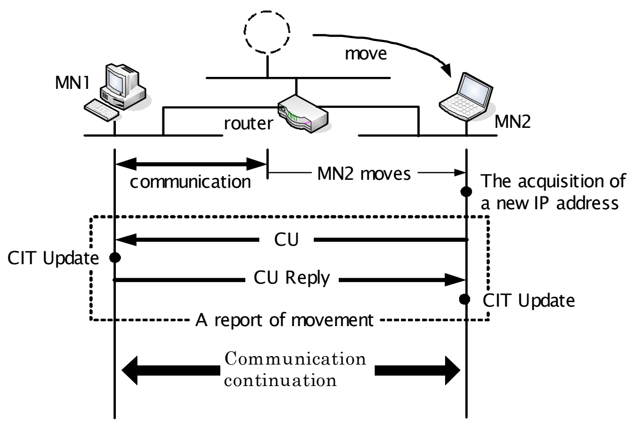

Figure 1. Address report sequence.

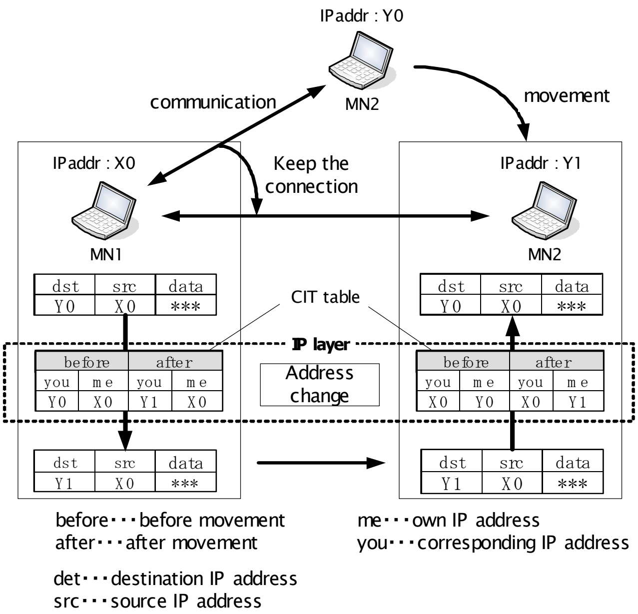

Figure 2. Procedures for IP address changes (MN1→MN2)

name and the IP address is used. DDNS is already in practical use. For the Continuous IP address resolution, Mobile PPC, which is the main theme of this paper, is used. In Mobile PPC, end terminals hold Connection Identifier Table (hereinafter, referred to as "CIT") which indicates the relationship between the IP address before movement and the IP address after movement by way of a connection identifier.

Fig. 1 shows the address report sequence in Mobile PPC. When MN2 moves to another network during the communication with MN1, MN2 acquires a new IP address from DHCP server at the new network. MN2 then generates CIT UPDATE (CU) packet, which includes the new IP address and the connection identifier, and sends it to MN1. MN1 updates CIT of its own based on the information reported by CU. MN1 sends back the CU Reply packet to MN2, and MN2 updates its own CIT. After the CU negotiation, IP addresses in the communication packets are changed in the IP layer of the end terminals according to the CIT records.

Fig. 2 shows procedures for IP address changes in case of the direction from MN1 to MN2 when the IP address of MN2 is changed from Y0 to Y1. The destination IP address field of the packet is changed from Y0 to Y1 according to CIT in MN1, and reversed from Y1 to Y0 according to CIT in MN2. Similar address changes are executed in the opposite direction of packets, and in this way packets are correctly routed, and the changes of IP addresses are concealed to higher layer software. With this method, mobility is realized with only end terminals.

B. A handover process in Mobile PPC

In this paper, the term "handover" means a change of its association with an Access Point (AP) in wireless LAN. There are two types of handovers; namely, one is a handover within the same sub-network, and the other is a

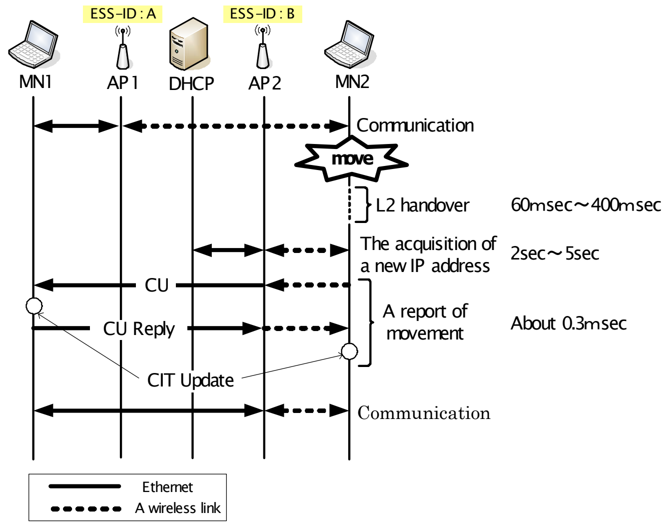

Figure 3. Detailed handover sequence in Mobile PPC

handover over different sub-networks. In the latter case, the IP address of a terminal changes, and this is the main subject of the discussion in this paper.

The same ESS-ID, which is a network identifier, is assigned to the APs in the same sub-network in general. The terminal recognizes its own sub-network by an ESS-ID. ESS-ID is reported by beacons which are periodically transmitted from APs. The terminal assumes that it moves over different sub-networks when a new AP has a different ESS-ID. The terminal requires a new IP address from a DHCP Server in the new sub-network and tries to continue the communication. Actually, this kind of mechanism has already been implemented in Windows PC.

Figure 3 shows a detailed handover sequence in Mobile PPC. It is assumed that MN1 and MN2 are first communicating with each other via AP1. When MN2 moves to another sub-network, MN2 executes a link layer handover (L2 handover) as the first step. L2 handover includes the searching for a new AP and the establishing a new association. When MN2 leaves the radio cell range of AP1 (ESS-ID: A), the association between MN2 and AP1 is cut off first, and then, MN2 searches for an accessible AP, and establishes a new association with AP2 (ESS-ID: B). Interruption of communication is inevitable because the transmission path is physically cut off. It takes about 60msec ~ 400msec to search for a new AP and to establish a new association [5]. Most of the time is spent for the searching of a new AP. L2 handover always occurs when MN2 changes its association with AP.

In the next phase, MN2 acquires a new IP address from a DHCP server through AP2 in a new sub-network. This operation includes DHCP sequence (DISCOVER, OFFER, REQUEST, ACK) and the checking of duplication of the IP address is executed by MN2 and the DHCP server. It takes about 2~5 seconds, and MN1 and MN2 can not communicate with each other during this rather long period of time because the IP address of MN2 is not yet determined. In the last phase, MN1 and MN2 make a CU negotiation of Mobile PPC, and CITs of MN1 and MN2 are updated. However, it takes only about 0.3 milliseconds, including the

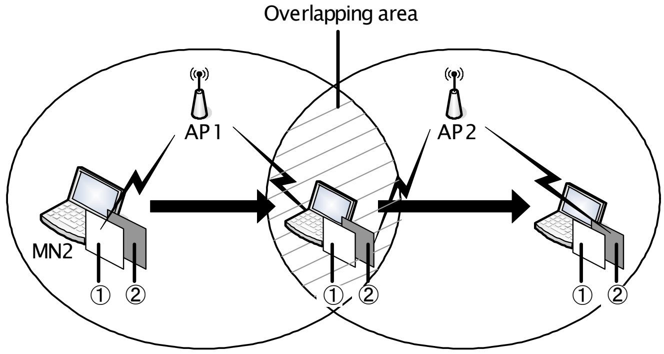

Figure 4. A process in a link layer

CIT update process and the CU negotiation time. This is very short compared to other interruption breaking times.

C. Problems of handover in Mobile PPC

CU packets sent from end terminals do not arrive at the correspondent node if MN1 and MN2 simultaneously move during communication. Both end terminals mutually send CU to the old addresses used before the movement, and accordingly they can never receive the packets. This problem is very serious because the communication is to break, besides the packet loss.

III. OUR PROPOSED METHOD

In this paper, we propose two measures to solve the problem. Namely, one is a measure in a link layer and the other is the remodeling of Mobile PPC. In the measure for the link layer, we use two wireless LAN cards in both MN1 and MN2, and make use of them simultaneously when they are to move during communication. With this measure, interruption of communication can be eliminated. Assuming the above measure, we then execute the remodeling of Mobile PPC that can resolve the problem of the simultaneous move of end terminals.

A. Measures in a link layer

Number equations consecutively with equation numbers in parentheses flush with the right margin, as in (1).

Figure 4 shows a process in a link layer. MN2 is equipped with two wireless LAN cards (①, ②). When MN2 exists in a radio area of AP1, it makes an association with AP1 with card ①. MN2 also executes with the card ② the processes such as measurement of radio strengths, channel scans, and confirmation of ESS-ID to look for a new AP that should be connected next. When MN2 moves to the overlapping area of AP1 and AP2, and the radio strength of AP1 becomes weaker than a certain value, MN2 decides to make a new association with AP2 with the card ②, keeping the communication with the card ①. Then, MN2 acquires a new IP address from the DHCP server with the card ②. Finally, MN2 sends CU to MN1 with the card ② and thus CITs of both end nodes are renewed. Then, MN2 communicates with MN1 using card ②, and after a certain period of time, MN2 cuts off the association of card ① with AP1. The reason why the card ① keeps its association for a while is that MN2 may receive packets destined to the old IP address. MN2 executes channel scan with card ① after having cut off the association with AP1. In this way, MN2

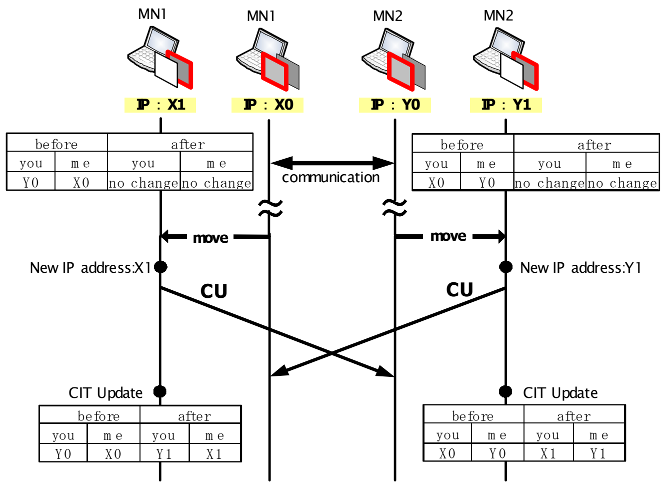

Figure 5. Sequence of the simultaneous move according to the remodeling process

can realize a packet-lossless handover in a link layer using two wireless LAN cards in turn.

The measures described above can be controlled by an application program. The commands to be used are shown below. FreeBSD5.3 is adopted as an operating system.

- Making an association with an AP
  ifconfig interface ESS-ID
- Getting information of neighboring APs
  wicontrol interface -L
- Acquiring an IP address from a DHCP server
  dhclient interface -r (to release an address)
  dhclient interface (to acquire an address)

B. Remodeling of Mobile PPC

Remodeling of Mobile PPC resolves the crucial problem caused by the simultaneous move of end terminals. It is assumed that the measure in a link layer described in 3.1 is adopted in advance.

If an end terminal receives a CU packet just after it sends a CU packet, it is considered that the two end terminals are moving at the same time. Even if the destination IP addresses of the packets are old, they can receive the packets because they both adopt the measure described in 3.1. The end terminals renew their CIT tables according to the remodeling process of Mobile PPC as shown below.

Figure 5 shows a sequence of a simultaneous move by the remodeling process. Both end terminals send CU to the old IP addresses of the correspondent terminals and wait for CU Reply as they do not know if the correspondent terminal is also moving at the same time. MN1 and MN2 can judge that the simultaneous moves are taking place, if they receive CU destined to the old IP address from the correspondent terminal just after sending CU. In this case, it is possible that MN1 and MN2 make a new CIT according to the information reported by CU from the correspondent terminal. In both end terminals, the field of "me" after movement in CIT is changed to new IP addresses. Also, the field of "you" after movement is changed to new IP addresses of the correspondent terminals reported by the CU packet.

With this method, CIT tables are modified correctly in the case of simultaneous movements, and the problem of communication breakage is resolved successfully.

IV. CONCLUSION

In this paper, we have proposed a packet-lossless handover in Mobile PPC based on the measure both in a link layer and Mobile PPC. The measure in a link layer makes it possible to communicate with both of the new IP address and the old IP address during communication by using two wireless LAN cards at both end terminals. Also the serious problem of communication breakage that occurs when end terminals move simultaneously has been solved by the remodeling of Mobile PPC. In the near future, we will put this system into practice to confirm its effectiveness.

REFERENCES

[1] Teraoka. F: “Node Mobility Protocol in the Internet”, IEICE Transactions on Communication vol.J87-DI No.3 P.308-328, March 2004 (in Japanese)

[2] C. E. Perkins.”IP Mobility Support for IPv4,”RFC 3344. Aug.2002.

[3] Motoki Takeuchi, Hidekazu Suzuki, Akira Watanabe, “Implementation and its evaluation on Mobile PPC realizing end-to-end mobility,” Proceedings of DICOMO2005 symposium,Vol.2005, No.6, pp.125-128, Jul.2005.

[4] Vixie (Ed.), P., Thomson, S., Rekhter, Y. and J.Bound, “Dynamic Updates in the DomainName System”, RFC 2136,April 1997.

[5] Arunesh Mishra and Minho Shin and William Arbaugh, “An empirical analysis of the IEEE 802.11 MAC layer handoff process,” ACM SIGCOMM Computer Communication Review, Vol. 33, Issue 2, pp. 93–102, April 2003.

[6] D.Johnson, C. Perkins, J. Arkko, “MobilitySupport in IPv6,” RFC3775. June 2004.

[7] R. Droms, “Dynamic Host Configuration Protocol,” RFC2131, March 1997.

[8] Ishwar Ramani and Stefan Savage, “SyncScan: practical fast handoff for 802.11 infrastructure networks,” Proceedings of INFOCOM 2005, vol. 1, pp. 675-684, March 2005

[9] R.Koodli, ed., “Fast handovers for mobile IPv6,” draft-ietf-mispshop-fast-mipv6-03.txt, Oct. 2004.

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Motivation

Background

- The spread of wireless LAN

→Wireless network environment has been increasing.

- The spread of mobile terminals

→The number of users carrying mobile terminals has been increasing.

Problems

- In TCP/IP, IP addresses change when the terminal changes its location.

⇒Communication is inevitably broken.

Realizing "mobility" in the Internet is useful.

Mobile IPv4

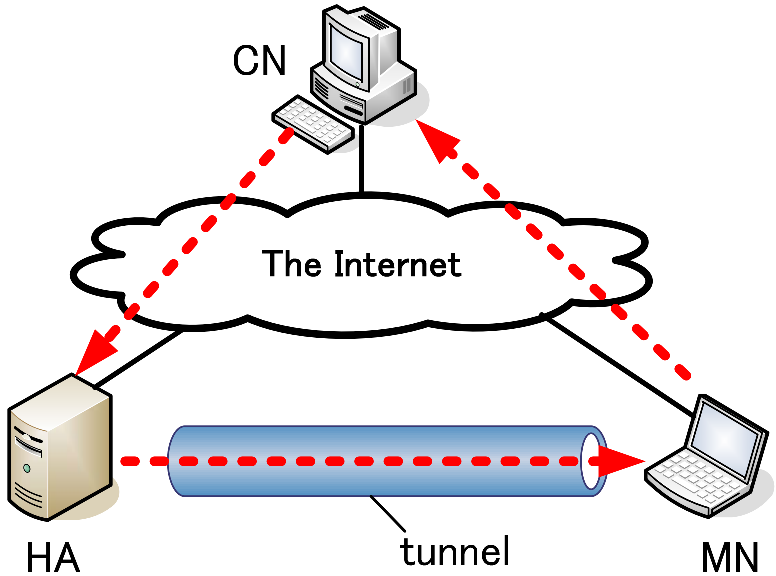
Existing Technology

Summary of the operation

- MN registers its current location to HA.
- Packets from CN to MN are relayed by HA using a tunneling technology.
- Packets from MN to CN are directly transferred.

Problems

- There is a redundancy of the communication path.
- An extra header is needed while the tunnel transmission.
- An extra device HA is needed.



Proxy server : Home Agent (HA)

CN : Correspondent Node
MN : Mobile Node

Mobile PPC

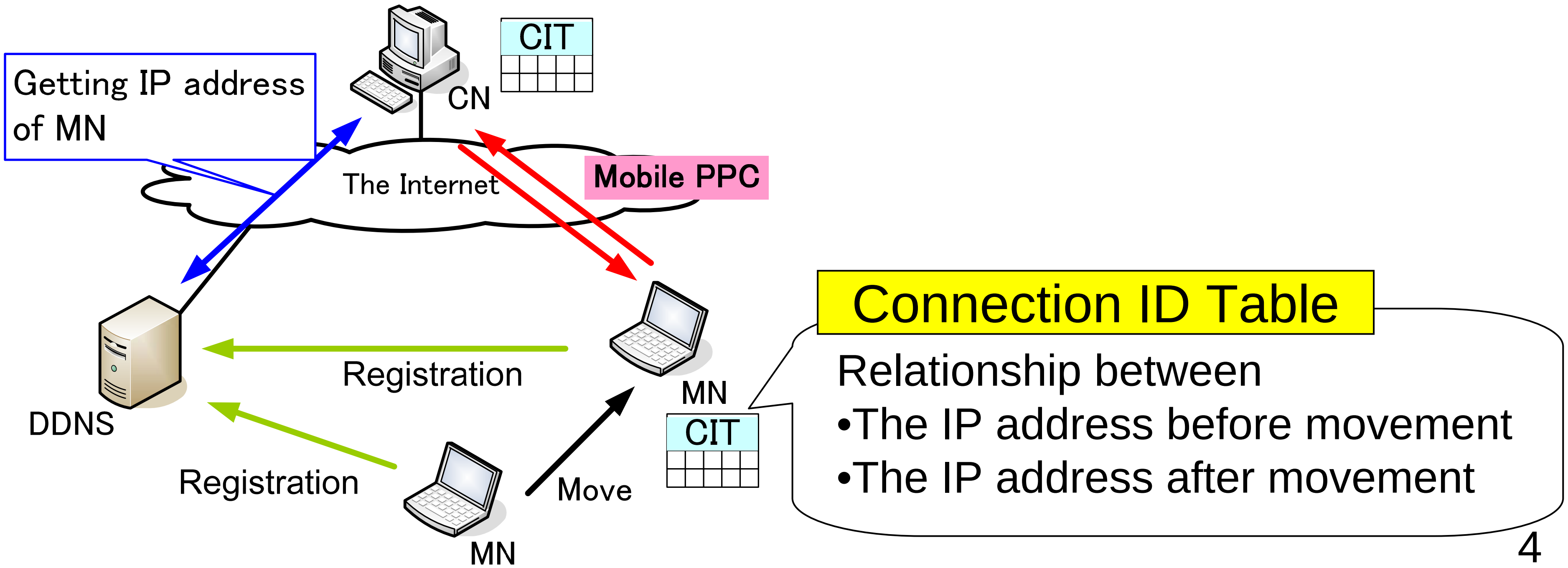
- **At the beginning of communication** — <u>**DDNS**</u> is used.

DDNS : An equipment which dynamically manages the relationship between the host name and the IP address.

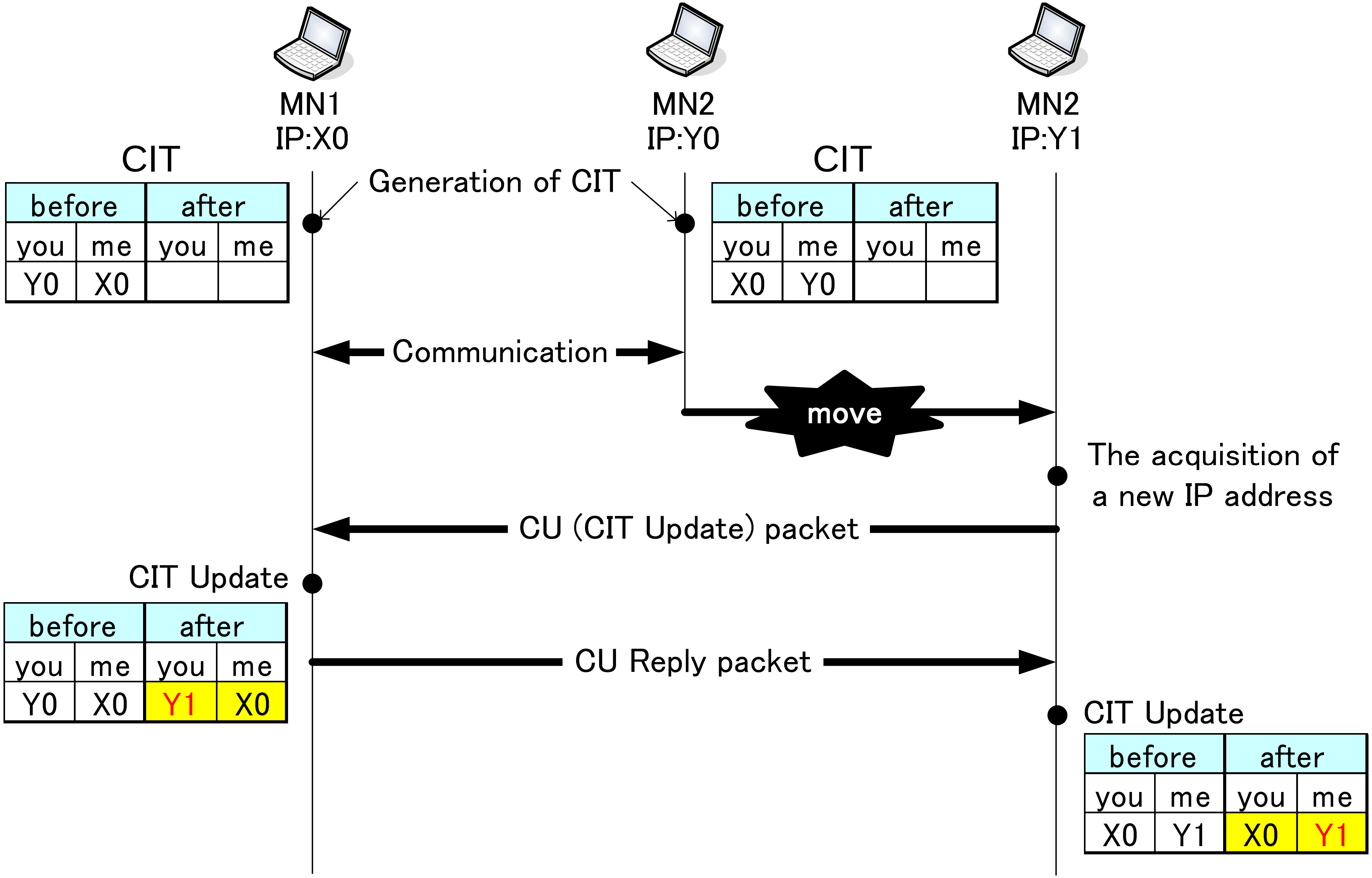
- **When the terminal moves during communication**

—CN and MN report the movement information each other directly.

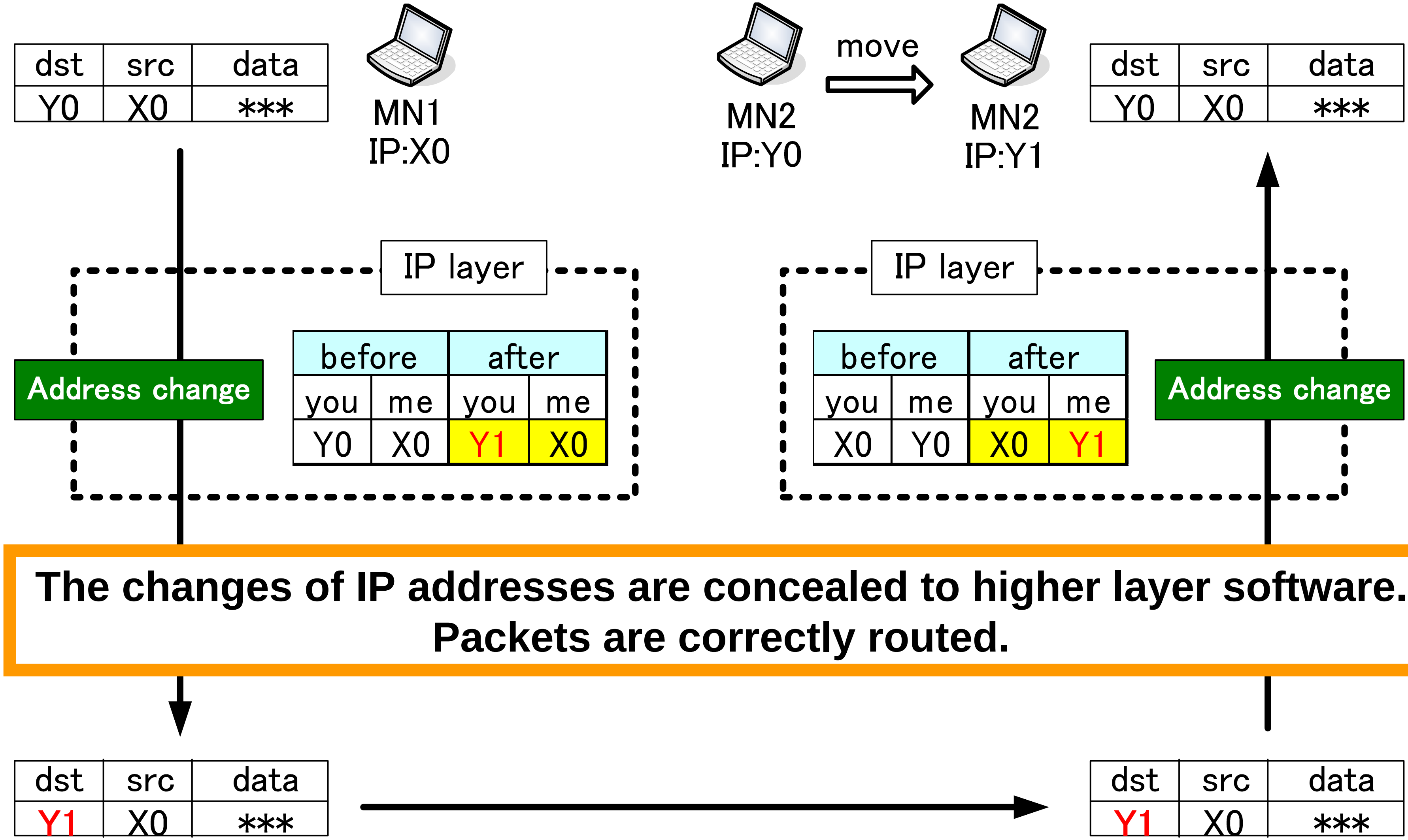
—IP address are changed according to CIT when they communicate.



Address report sequence in Mobile PPC

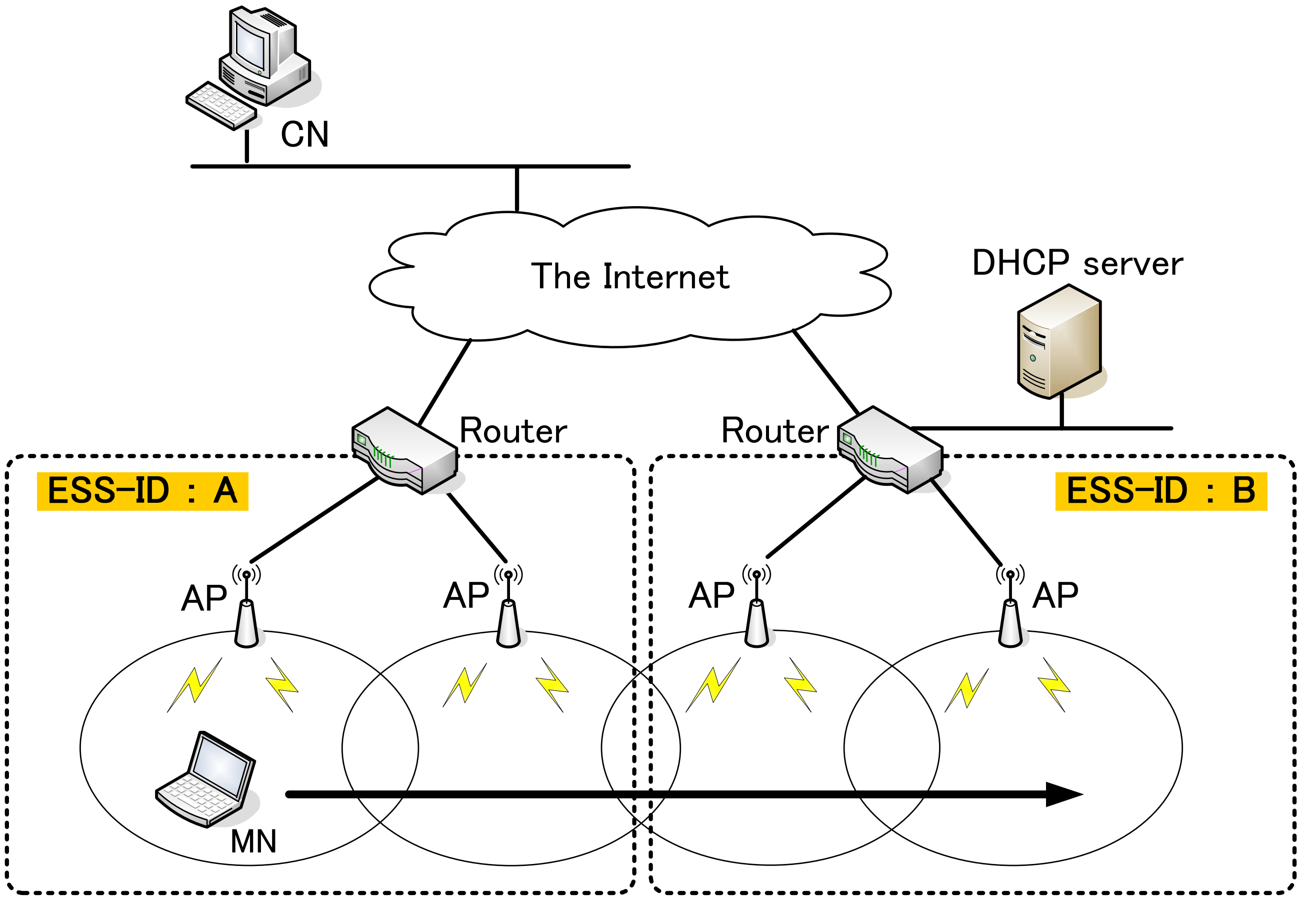


Communication in Mobile PPC



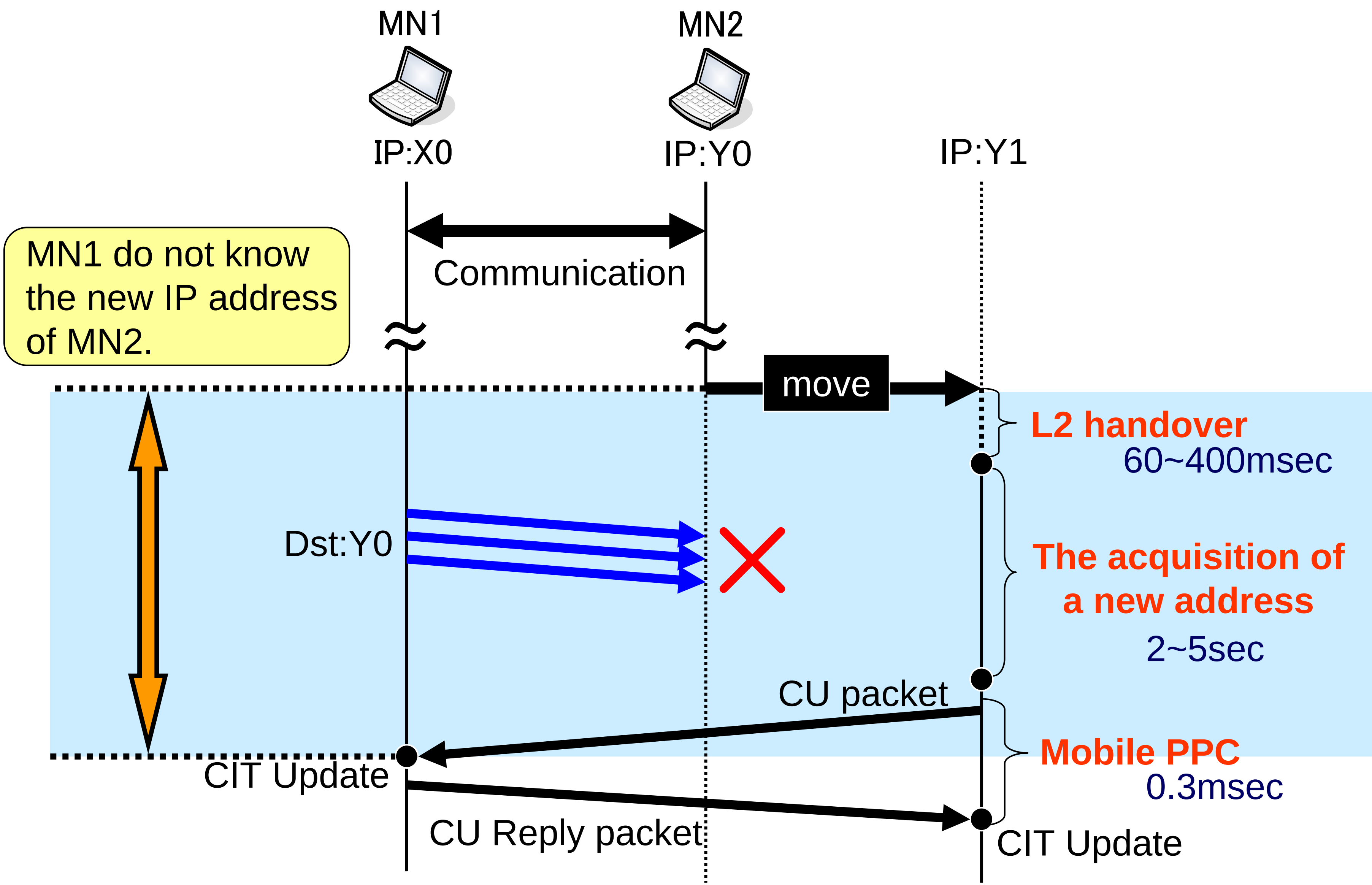
The changes of IP addresses are concealed to higher layer software.
Packets are correctly routed.

A handover



- L2 handover･･･MN changes APs physically
- L3 handover･･･an acquisition of a new IP address,
  an address report in Mobile PPC

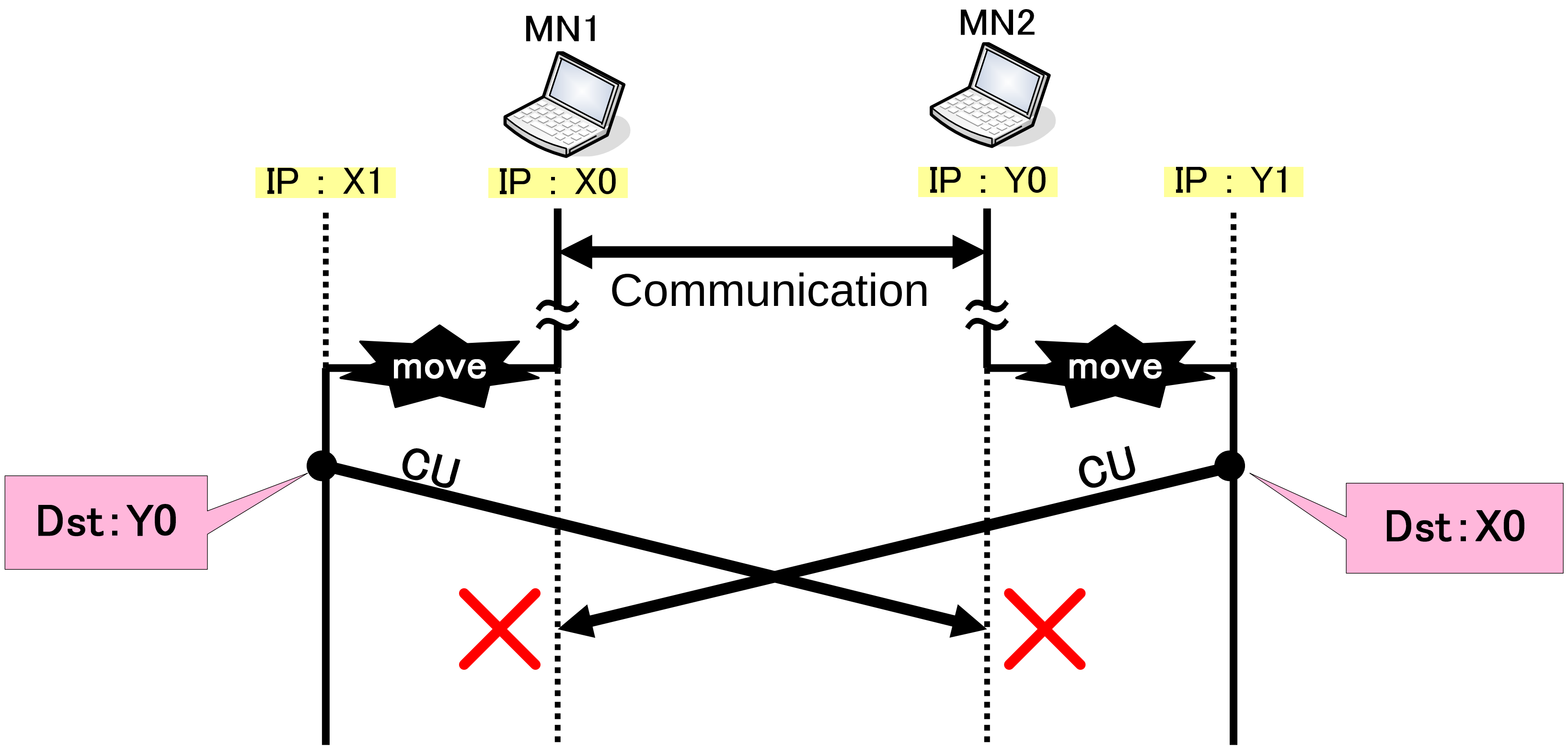
Factors of packet loss



Problems of a simultaneous move

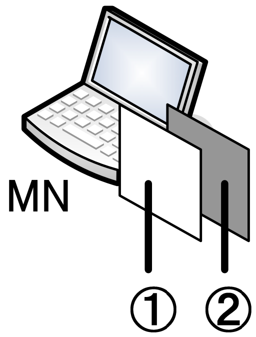
- If MN1 and MN2 move simultaneously during communication,

  ⇒CU packets sent from MN1 and MN2 do not arrive at the destination.



Proposed Method

Measures

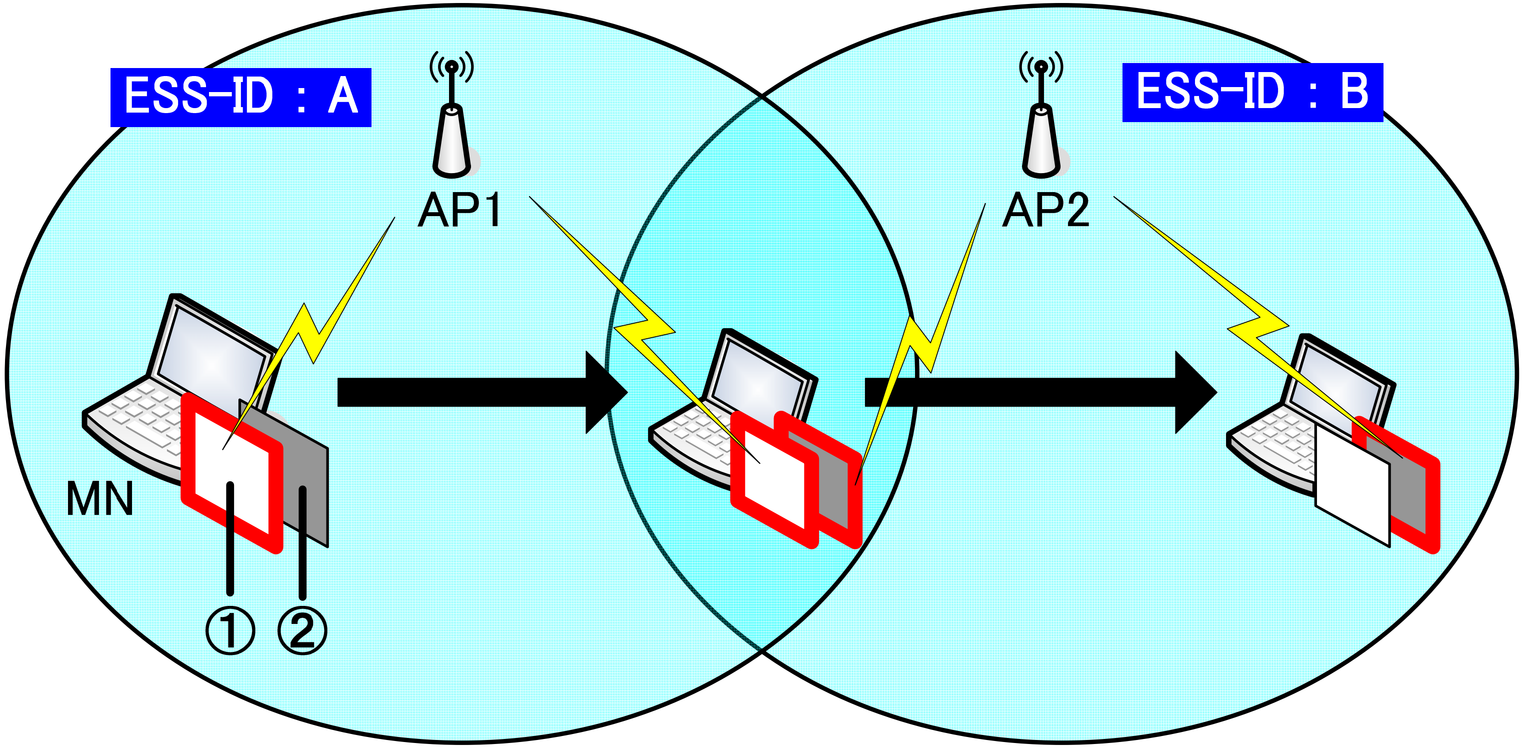


- Measures in a link layer
  - MN holds two wireless LAN cards (①,②).
    - One card is used for communication, and the other is used for standby.

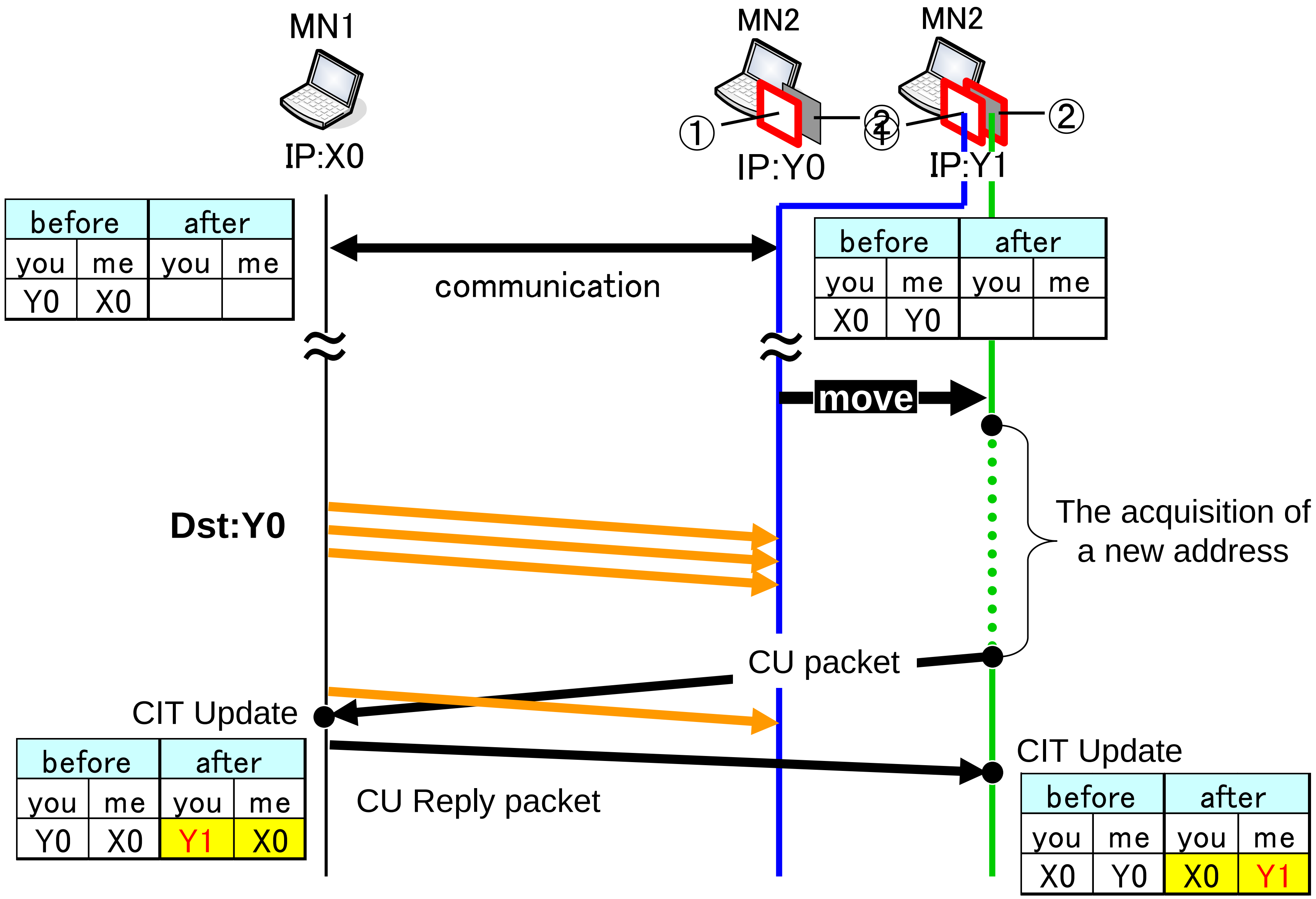
- Remodeling of Mobile PPC
  - The updating method of CITs is partly modified.

A process in a link layer

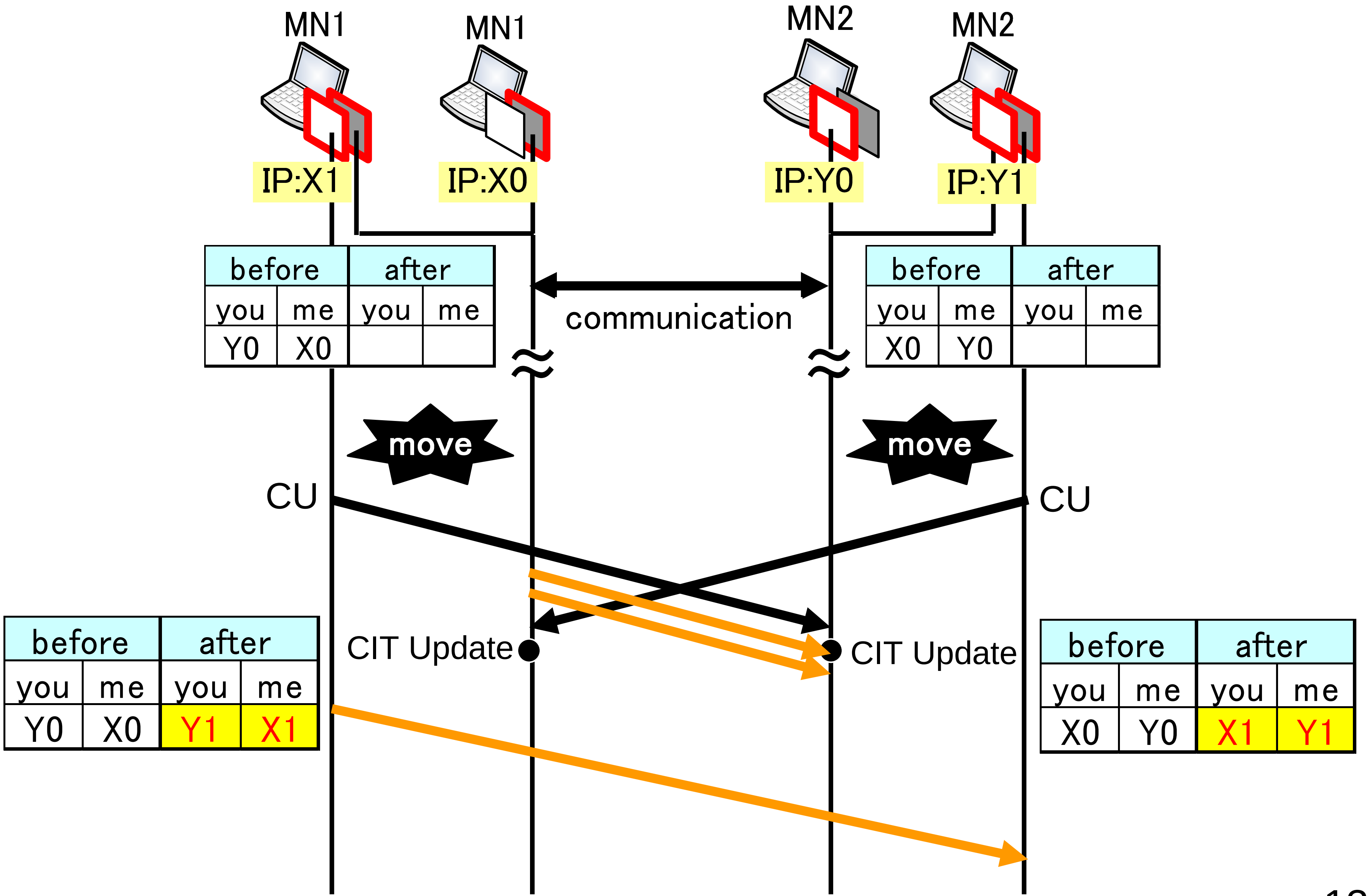
- Measurement of radio strengths
- Channel scans
- Confirmation of ESS-ID



Sequence of the move with two wireless LAN cards



Sequence of the simultaneous move after remodeling



Conclusion and Future Work

- Conclusion
  - Proposal of a packet-lossless handover in Mobile PPC
    - Using two wireless LAN cards in both end terminals, it becomes possible to communicate with both of the new IP address and the old IP address.
    - The communication breakage that occurs when end terminals move simultaneously has been solved by the remodeling of Mobile PPC.

- Future work
  - We will put this system into a practical use and confirm the effectiveness.