Mobile IP Technology

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Abstract

Mobile IP (Internet protocol) is recognized as a technology that supports ubiquitous service because it can provide seamless IP connectivity even when an IP terminal changes access method. This article describes the mechanism of Mobile IP and enhanced technologies and its applications.

1. Introduction

Wireless broadband services, e.g., high-speed mobile communication service (3^{rd} generation (3G) mobile phone service) and hotspot service using a wireless LAN, are regarded as important access technologies for providing ubiquitous service that allows users to communicate anytime, anywhere, and with anybody. Wireless LAN technology (e.g., IEEE802.11b/a) is used in users' home networks and in office networks. There are already many commercial services using wireless LAN technology. There are also many commercial services for fixed broadband access using optical fiber (FTTH: fiber to the home) or ADSL (asynchronous digital subscriber line). And there are demands for services that can use these wireless/wired methods selectively depending on the user's location or environment. On the other hand, IP mobility (mobility in the IP layer) that supports these different access methods and guarantees IP service connectivity during movement is attracting a lot of attention because it provides seamless mobility between different access methods and makes it easier to select an access method depending on the user's environment. We think that Mobile IP [1], [2] which is being discussed in IETF (Internet Engineering Task Force) [3] is the most appropriate protocol. It is a key network technology for achieving ubiquitous service. In this article, we explain the mechanism of Mobile IP and enhanced technologies and its applications.

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2. Mechanism of Mobile IP

Mobile IP technology is being discussed in IETF Mobile IP WG[*1]. Mobile IPv4 was standardized as RFC 3220, entitled IP Mobility Support for IPv4. Mobile IPv6 was standardized as RFC3775 (RFC: request for comments).

Mobile IP (**Fig. 1**) uses a location management agent called Home Agent (HA) that maintains the relationship between a home address assigned to a mobile node in the home network and a care-of address assigned to it when it is visiting another network. HA lets Mobile IP deliver packets to the mobile node even if it is moving around different networks.

After moving from a home network to a visited network, a mobile node gets a care-of address and registers it with an HA. Packets sent to the mobile node are intercepted by the HA, which recognizes that the mobile node is currently out of the home network, and forwarded to the mobile node's care-of address by a tunneling mechanism. In Mobile IPv4, it is difficult to assign a different address to a mobile node in a visited network, Foreign Agent (FA) assigns its own address to mobile nodes by using agent advertisements and reduces the number of IPv4 addresses to support a large number of mobile nodes in the visited network. On the other hand, in Mobile IPv6 a mobile node can generate its own address by combining an interface ID with a network prefix advertised by a router. This mechanism is defined in the basic IPv6

*1 Mobile IP WG (Mobility for IPv6 working group) is an IETF working group. It mainly handles the basic functions of Mobile IPv6.

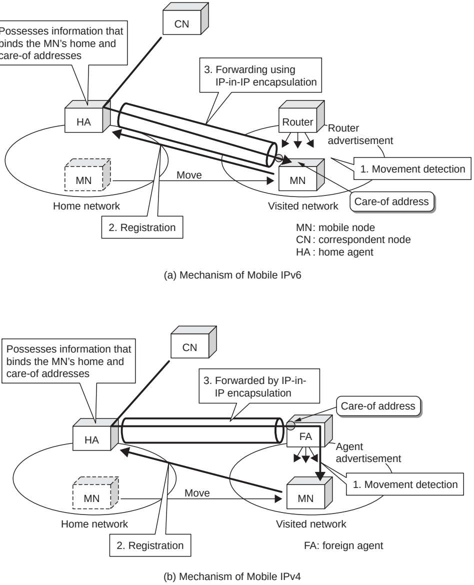

Fig. 1. Mechanism of Mobile IPv4/IPv6.

specifications, so Mobile IPv6 does not need FA.

Mobile IPv6 also supports a route optimization procedure in which the packet does not pass through HA. This procedure needs a mobile node to report its care-of address. The mobile node and the correspondent node must authenticate the registration message, but it is difficult to share a secret key between them because a mobile node communicates with many correspondent nodes. First, the mobile node must get the keys for the home and care-of addresses (shown by messages 1a/2a and 1b/2b, respectively, in **Fig. 2**). Then the mobile node sends a registration message (message 3 in Fig. 2) which includes two keys to the correspondent node. The correspondent node can recognize that the message was sent by the mobile node because these keys can be possessed only by the mobile node.

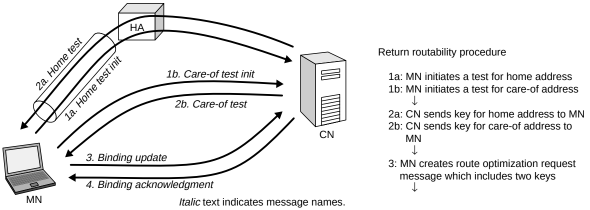

Fig. 2. Mobile IPv6 route optimization.

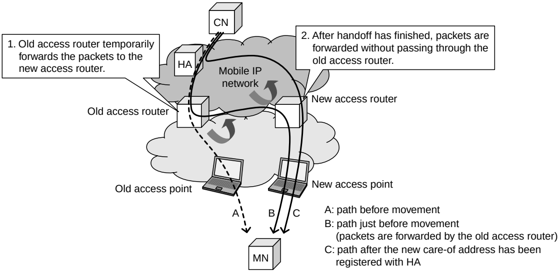

Fig. 3. Fast handoff mechanism.

3. Enhanced technologies for Mobile IP

This section describes enhanced technologies for Mobile IPv6.

3.1 Fast handoff

Fast handoff [4], which is being discussed in the MIPSHOP WG*2, aims to provide faster handoff*3. Features of this technology are (1) getting the care-of address used in the visited network before handoff and (2) forwarding packets from the previous access router in the old network to the new access router in the new network. These features can decrease the packet loss when a mobile node moves from one subnet to another subnet (**Fig. 3**).

3.2 Network mobility (NEMO)

NEMO [5] is discussed in the NEMO WG. Mobile IP provides a mobility function to each mobile terminal, and NEMO provides the same to the network (subnet). In NEMO, a mobile router (MR) detects movement, registers location information, and encapsulates/decapsulates packets (by IP in IP*4) instead of a mobile node. MR registers the home and care-of

*2 MIPSHOP WG (MIPv6 signaling and handoff optimization working group) is one of the IETF working groups that defines the scope of items and tackles them. It mainly focuses on technologies that enables fast movement.

*3 Handoff: the process in which control is shifted from one base station to another while the mobile node is communicating. Handoff occurs when the mobile node changes access point in one subnet or when the mobile node changes not only access point but also IP subnet. Mobile IP mainly handles handoffs between IP subnets.

*4 IP-in-IP encapsulation: An IP packet is forwarded to the destination address included in the IP header. IP-in-IP encapsulation can deliver to the IP address included in an IP header that was added to the original IP packet.

addresses and network prefix of the network for which it is providing mobility. HA intercepts packets for the network prefix and forwards them to MR in the visited network (**Fig. 4**). NEMO does not provide route optimization, which would shortcut MR's HA. This function is currently out of the scope of NEMO WG, but it will be discussed after NEMO's basic functions have been standardized.

3.3 Hierarchical Mobile IP

Hierarchical Mobile IP [6] is being discussed in MIPSHOP WG. This technology is for reducing the registration round-trip time. As shown in **Fig. 5**, Hierarchical Mobile IP deploys a new agent called a Mobility Anchor Point (MAP) in the middle of the path between MN and HA. HA and MAP form a hierarchical architecture that manages MN's mobility.

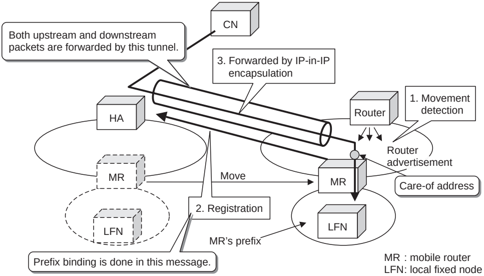

Fig. 4. Network mobility mechanism.

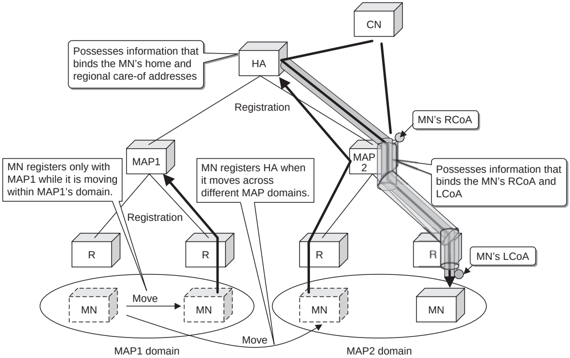

Fig. 5. Hierarchical Mobile IP mechanism.

MN registers an address that belongs to MAP's prefix (the address is called the regional care-of address (RCoA)). When MN moves within MAP's domain, it reports its local address (called the local care-of address (LCoA)) only to MAP. This reduces the registration round-trip time and the load on HA.

4. Applications of Mobile IP

Mobile IP and NEMO provide continuous communication even if MN and MR change their addresses. These technologies can be applied to the following services (**Fig. 6**).

(1) Seamless mobility between different access methods

MN and MR can select an appropriate access method depending on their locations and use services seamlessly. If both 3G wireless and a wireless LAN are available, then MN/MR uses the wireless LAN if it is in a hotspot area and 3G wireless if it is not. Mobile IP does not define how to select these access methods. The selection policy depends on the application software. After selecting an access method, MN/MR can get the care-of address and perform handoff by using Mobile IP. This kind of handoff function has already been implemented in some commercial MN products. MRs with this function are also being used in trials [7].

(2) Roaming services (VPN service and xSP connectivity/roaming)

Users outside their home network can use IP addresses that are being used in their home network. This lets them access their home network's services (e.g., ISP connectivity services and an intranet) when servers at the ISP and intranet control access based on the IP addresses.

(3) Various application services that use user location information

A ubiquitous network can deliver appropriate information (e.g., local information) by referring to the user's location. HA maintains only care-of addresses. These addresses are used to get geographical information by using some servers that have mapping information between network prefixes and geographical information.

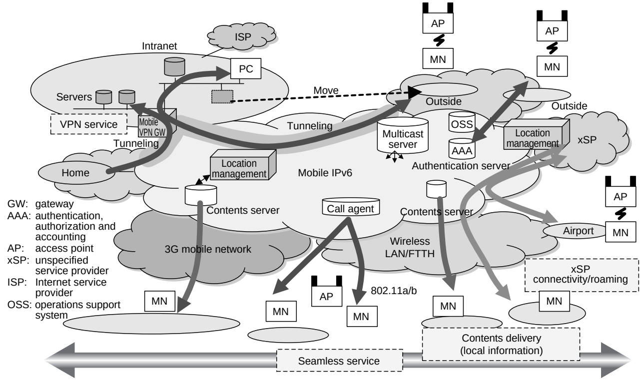

Fig. 6. Services using Mobile IP.

5. Future work

Two points need to be considered in deploying Mobile IP technologies: scalability and terminal variety. Key technologies for scalability include bootstrapping procedures that support MNs to configure parameters and enhanced Mobile IP technologies (e.g., fast handoff and hierarchical Mobile IP) discussed in MIPSHOP WG. Terminal variety refers to the kinds of mobile IP terminals that will appear. There are already several Mobile IP implementations for PCs and PDAs (personal computers and personal digital assistants). If a Mobile IP function is applied to small devices (e.g., sensors), they will be able to connect to an IP network regardless of their location. Mobile IP is regarded as a key technology for providing mobility in the ubiquitous society in which many things will be connected to an IP network.

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