Global Dynamic Home Agent Discovery on Mobile IPv6

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Summary
Mobile IPv6 is a novel technology that supports mobile Internet communications. When a mobile node approaches another scalable domain, such as another ISP or mobile network company, serious problems occur such as registration delay and transmission latency owing to the binding update that the mobile node registers back to its original home agent. This work attempts to construct a scalable mobile IPv6 global network anycast by dynamically determining the nearest home agent to the current home agent for registration and transmission. This scheme is called Global Dynamic Home Agent Discovery (GDHAD). This investigation also performed and evaluated an anycast simulation to find how to obtain the best performance.
***Keywords*:** Anycast, mobile IPv6, Internet

1. Introduction

Mobile IPv6 [5] is a novel technology that supports mobile Internet communications. On the mobile IP network, each mobile node (MN) is recognized by its home address, regardless of its current attachment point. When moving from the home link to a foreign link, a mobile node (MN) obtains a care-of-address (CoA) from either a stateless address by auto-configuration or a stateful address from DHCPv6. The binding update (BU) is employed by a mobile node informing its home agent (HA) for a new registration or by a correspondent node (CN) connecting its (CoA). Generally, an HA constructs a tunnel to the mobile node's CoA to forward the datagram sent by the correspondent node. Unfortunately, if the mobile node moves toward another scalable domain, such as a different ISP or mobile network company, then serious problems such as registration delay and transmission latency may occur because of the binding update that the MN registers back to its original home agent. Some proposals, such as smooth hand-off techniques [3] and hierarchical mobile IPv6 [15] remain unresolved.

Data communication on the next-generation Internet can be achieved by unicast, multicast and anycast. Unicast functions by point-to-point datagram communication between a source and a destination node sending the datagram to the one recipient identified by the unicast address. Multicast works by point-to-multipoint datagram communication between a single source and one or more destination nodes, transmitting one copy of a datagram to a group of members to reach all recipients identified by the multicast group address. Anycast, the new IPv6 protocol, operates by point-to-point datagram communication between a single source and its nearest destination node. Choosing the nearest node based on the network topology is called 'network anycast'. The metrics of network anycast are cost, number of router hops and calculated distance. By contrast, the metrics of the application anycast include available server capacity, measured response times and number of active connections and so on. Anycasting has many merits in a mobile network, including resource reduction, simplified configuration, network resiliency and load balancing.

The Dynamic Home Agent Address Discovery (DHAAD) in [5] is an anycast application. DHAAD uses anycast technology to achieve loading balance of home agents. Multi-HAs must all be assigned the same subnet in the protocol as illustrated in Fig. 1. These HAs are gathered in the same link in the DHAAD protocol architecture. When the MN sends a binding update to the HA, it transmits an ICMP Home Agent Address Discovery Request Message with an anycast IP address in the destination section of the IP header. One HA in the local link receives and replies to the ICMP Home Agent Address Discovery Reply message including the HAs' unicast IP list. When the MN receives the ICMP's reply, it sends a binding update to a selected home agent with the HA's unicast IP. Then, the home agent employs Proxy Neighbor Discovery to intercept any IPv6 packets addressed to the MN's home address on the home link.

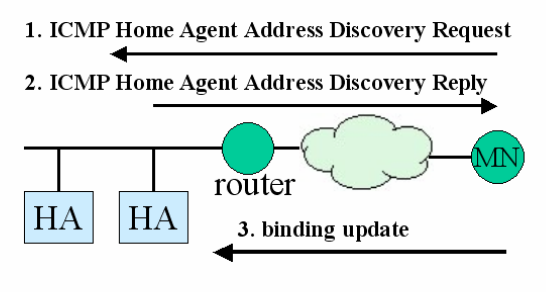
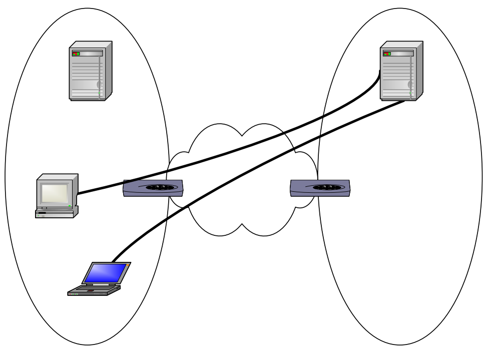


Fig. 1: Dynamic Home Agent Address Discovery

The mobile network enables MNs to effectively communicate with one another, but still has some unresolved problems. For instance, route optimization (RO) enables the mobile node delivering a datagram to directly connect to its correspondent node, but also raises the handoff delay and causes difficulties in IPSec. Route optimization must accomplish the activity return routability (RR) procedure [5] in advance, as well as the notification between MN and CN through HA by a correspondent registration. Security problem is also a major issue in route optimization. However, without route optimization, the mobile and correspondent nodes might not be easily able to reconnect to the original HA if they are not in the same domain (see Fig. 2(a)). The performance of registration time and transmission delay would be the worst case without route optimization. This study proposes a Global Dynamic Home Agent Discovery (GDHAD) scheme by global network anycast to identify the nearest HA to the mobile node, permitting the mobile and correspondent nodes to interconnect closely at low cost (see Fig. 2(b)).



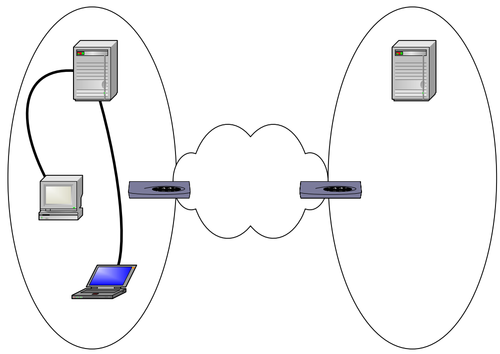


Fig. 2: MN registers to HA in the different domain

The rest of this work is organized as follows. Section 2 describes the background and anycast Mobile IP. Section 3 presents the proposed scheme in detail. Section 4 describes the analysis and simulation results. Conclusions are finally drawn in Section 5.

2. Background and Anycast Mobile IPv6

2.1 Background

Initially, routers periodically send router advertisement (RA) message periodically on the home link. Once the MN successfully connects to the home link, it obtains a permanent address and discovers the HA's address from an RA message. When an MN moves to a visited network by a foreign link, it obtains a transient address as a care-of-address (CoA) by the stateless autoconfiguration or by the stateful DHCPv6 server via a router advertisement message. The CoA assigned to the MN has its foreign network prefix on its foreign link. The MN sends a binding update to the HA to register its new location. After receiving the binding update (BU) message, the home agent sends a binding acknowledge (BA) message back to the mobile node. Then, the HA sends a Proxy Neighbor Discovery on the home link to find the mobile node.

When the correspondent node initiates a connection, the router sends datagram to the MN's IP address to replace the HA's MAC. The HA builds a tunnel, encapsulates the datagram and sends to the MN. The MN replies directly to the correspondent node with datagram or a piggyback binding update message. Hereafter, the correspondent node sends packets directly to the mobile node. The mobile node is also addressable at more than one CoA that may accept datagram at the same time. When the MN moves, it remains reachable to the previous link.
A binding update message is used by a mobile node to inform its home agent of a new

registration, and by a correspondent node to connect to its care-of-address. A binding acknowledgment message acknowledges the binding update message. A binding refresh request message rebuilds a binding with the correspondent node when the cached binding is in use but its lifetime has expired. The binding error message is used by the correspondent node to alert an error related to mobility, such as an inappropriate attempt to use the home address destination option without an existing binding. This route optimization functionality integration allows direct routing (i.e. from any CN to any MN) to pass through the mobile node's home link, thus eliminating the triangle routing problem in mobile IPv4.

Mobile IPv6 also defines a new IPv6 destination option: the Home Address destination option, which is carried by the destination option extension header (next header value = 60). The Home Address destination option is applied in a datagram sent by a mobile node while being away from home to inform the recipient of the mobile node's home address. Mobile IPv6 also provides new ICMPv6 message types supporting dynamic home agent address discovery, renumbering and mobile configuration mechanisms. The new ICMP message types employed for home agent address discovery are: (1) ICMPv6 type field value = 144, Home Agent Address Discovery Request message, and (2) ICMPv6 type field value = 145, Home Agent Address Discovery Reply message. Message types used for network renumbering and address configuration on the mobile node are: (3) ICMPv6 type field value = 146, Mobile Prefix Solicitation message, and (4) ICMPv6 type field value = 147, Mobile Prefix Advertisement message.

2.2 Anycast Mobile IPv6

The network anycast spans an anycast group into the all-distributed HA and border router on the global mobile IPv6 (see Fig. 3). As a multicast network demands that all routers support multicast, so an anycast network needs all servers and routers to support anycast. Fig. 4 illustrates the anycast Mobile IPv6 framework. All border routers support anycast enabling datagram to be transmitted to the nearest HA. The CN can connect to the mobile node's nearest HA, or even directly to the mobile node in the complete anycast mobile IPv6 framework, because the mobile node and HA are both anycast route destinations. All border routers in an anycast mobile IPv6 network can analyze the destination anycast IP in the datagram's header and forward the packet to the related interfaces. Then, the datagram is sent to the mobile node or a home agent through the anycast route. Thus, the HA is not mandatory in an anycast mobile IPv6 framework because datagram can be sent directly to the mobile node directly. However, anycast routing is defined as less variant routing, meaning that routing tables are not frequently exchanged. In Mobile IPv6, the mobile node always moves, but the router near the correspondent node's routing table does not have the present record of MN's anycast IP. The HA must still ensure that the packet has been forwarded to the mobile node correctly. Additionally, the mobile node also needs the HA during MN handoff. The MN sends a binding update to the HA when it moves to another base station range. Then, the HA tunnel the streaming to the new MN location. Although Mobile IPv6 has a routing optimization procedure for sending binding updates to the correspondent node directly, the return routability (RR) must be accomplished first. The return routability procedure must be also executed through the HA.

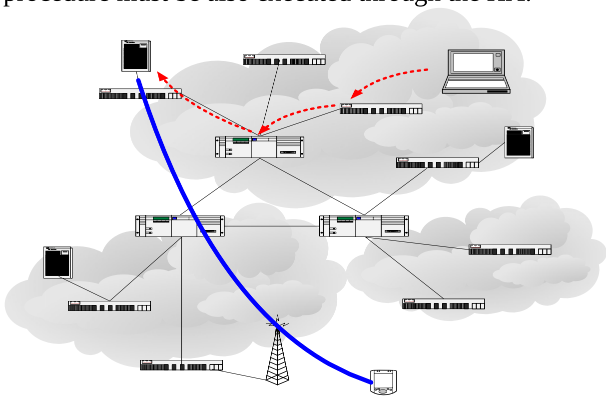


Fig. 3: Mobile IPv6 network

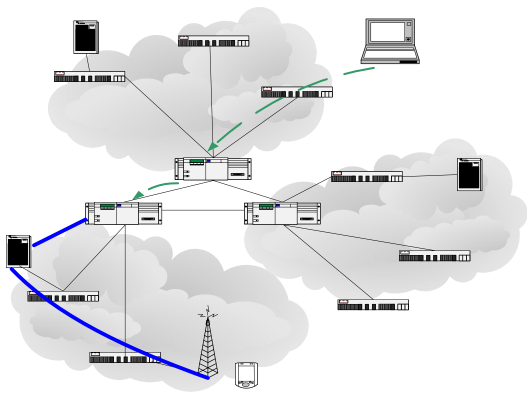


Fig. 4: Anycast Mobile IPv6 Network

The Subnet-Router anycast IPv6 address format is defined in [7]. Within each subnet prefix, an anycast address is taken from the unicast address space shown in Fig. 1. D. Johnson [12] also defines an additional group of reserved anycast addresses within each subnet prefix (see Fig. 5) and lists the reserved subnet