Internet Draft

Jaehoon Paul Jeong
Kyeongjin Lee
Jungsoo Park
Hyoungjun Kim
ETRI

draft-jeong-nemo-ro-ndproxy-02.txt
Expires: August 2004
14 February 2004

ND-Proxy based Route and DNS Optimizations for Mobile Nodes in Mobile Network

Status of this Memo

Abstract

This document specifies a mechanism for enabling mobile nodes in IPv6 mobile network to perform route and DNS optimizations. The route optimization is possible because mobile router relays the prefix of its care-of address to its mobile nodes by playing the role of ND-proxy. Through binding updates associated with the network prefix of an access network, the mobile nodes can perform route optimization. In addition, this document explains how mobile nodes can optimize its DNS name resolution through RA-based DNS discovery. By announcing the address of local recursive DNS server, mobile router allows mobile nodes using the DNS server to optimize their DNS name resolutions without additional overhead of finding DNS server.

Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [2].

Table of Contents

1. Terminology

This document uses the terminology described in [3]-[8]. Especially, four important terms are defined as follows [6][8]:

Multilink Subnet (MS)

A collection of independent links, connected by routers, but sharing a common subnet prefix.

ND-Proxy

A router proxying and relaying for all nodes on its router-mode interfaces except proxy-mode interfaces among its network interfaces.

Multilink-Subnet Router (MSR)

A router which has interfaces attached to different links in a MS, and which plays the role of ND-Proxy.

Recursive DNS Server (RDNSS)

A Recursive DNS Server is a name server that offers the recursive service of DNS name resolution.

2. Introduction

Recently, the demand and necessity of network mobility (NEMO) [3] is increasing along with those of host mobility based on Mobile IPv6 (MIPv6) [9]. The purpose of network mobility is to guarantee the continuity of the sessions of fixed nodes or mobile nodes (MN) within mobile networks, such as car, bus, subway train, airplane and submarine. The current solution is based on bi-directional tunnel between home agent (HA) and mobile router (MR) [3]. The basic support protocol of NEMO enables mobile network node (MNN) [7] and correspondent node (CN) to communicate through the bi-directional tunnel. Data exchange between MNN and CN is performed not via optimal routing path, but via the non-optimal path including bi-directional tunnel. MR's HA intercepts all of packets destined to the MNNs and tunnels them to the MR. Also, the MNNs' outbound packets are tunneled in order to pass ingress filtering [3][9]. This mechanism is very simple but it gives up a powerful feature of MIPv6, route optimization (RO) without ingress filtering. In addition, when the mobile network has multiple nested MRs, packet delay between MNN and CN becomes longer because of dog-legged routing and also packet size becomes bigger due to extra IPv6 header attached to packet per level of nesting [10].

When we think over the applicability of NEMO in our daily life, we can forecast that network mobility service will be provided in

vehicles, such as bus, subway train and airplane, because most passengers in such vehicles will have hand-held PC or PDA as MN rather than fixed node in near future. Therefore, it is necessary to provide route optimization for such MNs. This document describes a way of optimizing the routes between MNs and CNs, independently of the level of nesting and without the extra IPv6 header. The route optimization mechanism is based on the proxying function of MR, which informs MNs within mobile network of the access network prefix to make a care-of address (CoA) passing ingress filtering, and also relays packets between access router and MN. This proxying for RO is performed through IPv6 Neighbor Discovery (ND), which is called ND-Proxy.

3. Overview

```
                 +----+  ******************    +----+
                 |CN1+---*     Internet    *---+CN2|
                 +----+  ******************    +----+
                                  |
                                  |
                                +-+-+
                                |AR1|
                     RA(AR1_P)| +-+-+
                              V   |
        ----------+---------------+---------------+----------- Link1
                  |Proxy-mode                     |Proxy-mode
                +-+-+  +-------+                +-+-+  +-------+
                |MR1+--+RDNSS1|                 |MR2+--+RDNSS2|
     RA(AR1_P)| +-+-+  +-------+     RA(AR1_P)| +-+-+  +-------+
              V   |Router-mode                V   |Router-mode
         ---+-----+-----+--- Link2      ---+-----+-----+--- Link3
            |           |                  |  Proxy-mode|
          +-+-+       +-+-+              +-+-+        +-+-+
          |MN1|       |MN2|              |MN3|        |MR3|
          +---+       +---+              +---+        +-+-+ | RA(AR1_P)
                                             Router-mode|   V
                                               ---+-----+-----+--- Link4
                                                  |           |
                                                +-+-+       +-+-+
                                                |MN4|       |MN5|
                                                +---+       +---+
```

Figure 1. Multilink Subnet for Route Optimization

The route optimization is possible by MR's performing ND-Proxy, which makes a CoA with the prefix advertised by access router and relays the prefix of access network into the whole mobile network. Each MN can make its new CoA with router advertisement message including access network prefix and perform the return routability and binding update procedure. As ND-Proxy, the MR performs neighbor discovery for the sake of the MNs within its mobile network. Like this, through MR that performs ND-Proxy, access network and mobile network are configured into a multilink subnet. Figure 1 shows an example of a multilink subnet comprised of four links from Link1 to Link4. Two MRs, MR1 and MR2, receive the prefix information of access network (AR1_P) that was sent by an access router, AR1 as proxy-mode and relay it to their subnet link as router-mode [6]. Let's assume that the MNs, MN1 and MN2, move into the mobile network managed by MR1 like Figure 1. Also, let's assume that these visiting mobile nodes (VMN) communicate with the correspondent nodes, CN1 and CN2,

respectively. If these visiting mobiles can get the prefix of access network and make their new CoA, through the binding update with their correspondent node, they can communicate each other via an optimized path. This dissemination of access network's prefix is performed by MR which becomes attached to a foreign access network, not its home network. Likewise, MN3 can optimize the route through MR2. MN4 and MN5 can perform route optimization through MR2 and MR3, too.

The optimization of DNS name resolution is possible by MR's announcing the address of local recursive DNS server as well as the prefix information of access network. In Figure 1, by DNS Server option included in RA message, MR1 announces the address of Recursive DNS Server, RDNSS1, within its mobile network to its router-mode link, Link2. Therefore, MNs within Link2, MN1 and MN2, can optimize their DNS name resolution by using local DNS server, RDNSS1.

4. Neighbor Discovery extension

In order to support the route optimization, ND implementation in MR and MN must be extended to process the prefix information option for RO and that in Local Fixed Node (LFN) within mobile network, which has no mechanism for MIPv6, need no change.

4.1 RO Prefix Information option format

The mechanism of this document needs a new O (Route-optimization) flag within prefix information option for route optimization [4]. When this flag is set on, it indicates that the prefix included in the option can be used by MNs within a mobile network for route optimization. Figure 2 shows the format of the modified prefix information option, RO Prefix Information option, which is included in RA message.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |    Length     | Prefix Length |L|A|O|Reserved1|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Valid Lifetime                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Preferred Lifetime                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Reserved2                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                                                               +
|                                                               |
+                            Prefix                             +
```



```
|                                                               |
+                                                               +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 2. Prefix Information Option Format for Route Optimization

Field:

O   1-bit route-optimization flag. When set indicates that this prefix can be used for the route optimization of MNs within a mobile network.

The RO Prefix Information option provides an MN with the network prefix of access network and allows it to autoconfigure its new CoA through stateless address autoconfiguration and to perform binding update. The Prefix Information option appears in RA message and MUST be silently ignored for other messages. L (On-link) flag MAY be

either 0 or 1. Namely, this route optimization can be either on-link or off-link model [6]. A (Autonomous address-configuration) flag MUST be set on, indicating IPv6 stateless address autoconfiguration.

4.2 Neighbor Solicitation (NS) message format

NS message MUST be extended for Duplicate Address Detection (DAD) for the address based on RO prefix to be performed in the whole mobile network, not just within a link. Therefore, there is a need to discriminate between the normal NS message and extended NS message for route optimization [4]. Figure 3 shows the format of the modified NS message.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |     Code      |          Checksum             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|M|                           Reserved                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                                                               +
|                                                               |
+                       Target IPv6 Address                     +
|                                                               |
+                                                               +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Options ...
+-+-+-+-+-+-+-+-+-+-+-+-
```


Figure 3. Extended Neighbor Solicitation Message Format

Fields:

M   1-bit multi-hop flag. When set indicates that this NS message SHOULD be relayed to the other links of a multilink subnet.

Target IPv6 Address

The IPv6 address of the target of the solicitation, e.g., CoA. It MUST NOT be a multicast address.

4.3 DNS Server option format

DNS Server option contains the IPv6 address of the recursive DNS server. When advertising more than one DNS Server option, an RA message includes as many DNS Server options as DNS servers. Figure 4 shows the format of DNS Server option [8].

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |     Length    | Pref  |       Reserved        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Lifetime                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                                                               +
|                                                               |
+                   IPv6 Address of DNS Server                  +
|                                                               |
+                                                               +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4. DNS Server Option Format

Fields:

Type   8-bit identifier of the option type (TBD: IANA)

Option Name	Type
DNS Server	(TBD)

Length   8-bit unsigned integer. The length of the option (including the type and length fields) in units of 8 octets SHOULD be 0x03 (3 x 8 = 24 octets).

Pref   The preference of a DNS server. A 4-bit unsigned

integer. A decimal value of 15 indicates the highest preference. A decimal value of zero means unspecified. The field can be used for load balancing of DNS queries with multiple RDNSSes according to local policy.

Lifetime 32-bit unsigned integer. The maximum time, in seconds, over which this DNS server is used for name resolution. MNs should contact the source of this information, MR, before expiry of this time interval. A value of all one bits (0xffffffff) represents infinity. A value of zero means that the DNS server must not be used any more.

IPv6 Address of DNS Server
Recursive DNS Server's address for DNS name resolution.

5. Mobile Router

MR MUST process Prefix Information option for Route Optimization and DNS Server option for DNS Optimization, which may be included in RA message.

5.1 Process of RO Prefix Information option

Only if the prefix announced by an access router is different from the prefix of an MR's Home Address (HoA), the MR MUST perform the role of ND-Proxy and relay the prefix information. Before MR advertises the prefix information through Router Advertisement (RA) message, it MUST set O flag indicating that this prefix can be used for route optimization of MNs, which are either local mobile nodes (LMN) or VMNs within the mobile network.

If an MN within a mobile network receives the new prefix information option through RA message and can recognize this option, it MAY prefer RO prefix information option to normal prefix information option that contains the mobile network prefix assigned by the MR's home network. By performing binding update with the prefix of the access network, the MN can optimize the routes between its correspondent nodes and itself.

ND-Proxy MUST join the solicited-node multicast addresses that correspond to the IPv6 addresses assigned to MNs for which it is proxying for processing ND messages related to the MNs [4].

5.2 Process of DNS Server option

If MR has its own local RDNSS like MR1 and MR2 in Figure 1, it SHOULD announce the address of RDNSS to its router-mode link(s).

If MR receives DNS Server option from its proxy-mode link(s), it SHOULD relay the option to its router-mode link(s) through its RA message. In the case where MR has its own local RDNSS, it announces the DNS Server option of its RDNSS with higher precedence than those of other RDNSSes.

5.3 Delivery of Data Packets

After an MN gets a new CoA within a mobile network and performs binding update associated with the address, the data packets of correspondent node toward the MN can be delivered to the access network to which the mobile network containing the MN is attached, via optimal path between the mobile and correspondent nodes.

When the access router of the access network receives the data packets toward an MN and there is no neighbor information for the MN, it multicasts normal Neighbor Solicitation (NS) message to the solicited-node multicast address of the destination IPv6 address in order to find out the link-layer address of the destination MN. The MR, knowing the link-layer address of the target, responds to the NS message by returning its own link-layer address in a unicast Neighbor Advertisement (NA) message as ND-Proxy, which knows the IPv6 addresses and link-layer addresses of MNs within its mobile network while forwarding their data packets along with neighbor discovery related to each destination node.

When the access router knows the link-layer address of next-hop toward the destination MN, it forwards the IPv6 data packets to the MR corresponding to the link-layer address. The packets are relayed to next-hop toward the destination node by MR until the packets arrive at the destination. Like this, in the case where the mobile network where the destination node is placed is multi-level, the packets may be relayed to the destination node by more than one MR according to the route information in each MR's destination and neighbor caches.

5.4 Movement of Mobile Router

When an MR moves into another access network and detects its movement by movement detection algorithm [9], it performs binding update with its HA with a new CoA based on the new access network prefix, and then relays the prefix for RO into its other router-mode interfaces. This allows the MRs and nodes to perform route optimization based on the new access network prefix. When the MR returns to its home network, it deregisters with its HA and advertises RA message that contains RO Prefix Information option for the previous access network prefix with Valid Lifetime and Preferred Lifetime set to zeroes and O flag set on, and also Prefix Information option for MR's mobile network prefix. The RO Prefix Information option SHOULD be advertised at least three times. This RA message allows the MRs and MNs below the MR explicitly to release their current CoA and to use the MR's mobile network prefix in order to configure their addresses according to MIPv6 protocol [9].

6. Mobile Node

MN MUST process Prefix Information option for RO and DNS Server option for DNS Optimization, which are included in RA message.

6.1 Procedure of Route Optimization

For RO, MN generates a new CoA based on the access network prefix and performs binding update for the CoA.

6.1.1 Generation of a new CoA

Whenever an MN receives RA message containing RO prefix information option that includes a new network prefix of access network, it makes a new CoA.

6.1.2 DAD for the new CoA

The MN performs DAD for the new CoA through the extended NS message. The NS message of DAD for the new address is disseminated by MRs, acting as ND-Proxy, in the entire mobile network where the MN is placed [6]. Each MR memorizes the DAD for returning NA message to the originator or relayer of the extended NS message for a while.

If there is no NA returned after DAD timeout, the MN configures the address as its new CoA in its network interface.

Therefore, the DAD for the link-local addresses and global addresses based on mobile network prefix assigned by home network is performed through normal NS message only within a link and the DAD for the

global addresses based on access network prefix is performed through

extended NS message within a multilink subnet, which is relayed by ND-Proxies.

6.1.3 Return Routability and Binding Update

After configuring the new CoA, the MN performs the return routability and binding update procedure of MIPv6 [9]. If the MN is VMN for the mobile network where it is present, or as LMN, moves into another link of the mobile network to which its home link belongs, it SHOULD perform binding updates with both its HA and CNs.

6.2 Procedure of DNS Optimization

The optimization of DNS name resolution is possible by MR's announcing the address of local RDNSS along with RO prefix information through RA message like in Section 5.2 [8]. The DNS server can exist either within mobile network or within access network. The address of RDNSS is delivered to MNs through DNS Server option, one of RA options. Especially, VMNs can optimize their DNS name resolutions effectively by using a local RDNSS.

7. Security Considerations

The route optimization and DNS optimization in this document does not add any other security problems to the NEMO, MIPv6, or ND protocol. Security issues regarding the ND protocol are being discussed in IETF SEND (Securing Neighbor Discovery) working group [11].

8. Copyright

9. Normative References

[1] Bradner, S., "The Internet Standards Process -- Revision 3", BCP 9, RFC 2026, October 1996.

[2] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[3] Vijay Devarapalli et al., "Nemo Basic Support Protocol", draft-ietf-nemo-basic-support-02.txt, December 2003.

[4] T. Narten, E. Nordmark and W. Simpson, "Neighbour Discovery for IP version 6", RFC 2461, December 1998.

[5] S. Thomson and T. Narten, "IPv6 Stateless Address Autoconfiguration", RFC 2462, December 1998.

[6] Dave Thaler and Chistian Huitema, "Multi-link Subnet Support in IPv6", draft-ietf-ipv6-multilink-subnets-00.txt, June 2002.

[7] T. Ernst and H.-Y. Lach, "Network Mobility Support Terminology",

draft-ietf-nemo-terminology-00.txt, May 2003.

[8] Jaehoon Paul Jeong et al., "IPv6 DNS Discovery based on Router Advertisement", draft-jeong-dnsop-ipv6-dns-discovery-01.txt, February 2004.

10. Informative References

[9] D. Johnson, C. Perkins and J. Arkko, "Mobility Support in IPv6", draft-ietf-mobileip-ipv6-24.txt, June 2003.

[10] Pascal Thubert and Marco Molteni, "IPv6 Reverse Routing Header and its application to Mobile Networks", draft-thubert-nemo-reverse-routing-header-03.txt, October 2003.

[11] J. Arkko et al., "SEcure Neighbor Discovery (SEND)", draft-ietf-send-ndopt-03.txt, January 2004.

11. Acknowledgements

The authors would like to acknowledge the previous contribution of Dave Thaler and Christian Huitema for ND-Proxy.

12. Authors' Addresses

Jaehoon Paul Jeong
ETRI / PEC
161 Gajeong-dong, Yuseong-gu
Daejon 305-350
Korea

Phone: +82 42 860 1664
EMail: paul@etri.re.kr

Kyeongjin Lee
ETRI / PEC
161 Gajeong-dong, Yuseong-gu
Daejon 305-350
Korea

Phone: +82 42 860 6484
EMail: leekj@etri.re.kr

Jungsoo Park
ETRI / PEC
161 Gajeong-dong, Yuseong-gu
Daejon 305-350
Korea

Phone: +82 42 860 6514
EMail: pjs@etri.re.kr

Hyoungjun Kim
ETRI / PEC
161 Gajeong-dong, Yuseong-gu
Daejon 305-350
Korea

Phone: +82 42 860 6576
EMail: khj@etri.re.kr