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**Multihoming for Small-Scale Fixed Networks  
Using Mobile IP and Network Mobility (NEMO)**

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## Abstract

Multihoming technology improves the availability of host and network connectivity. Since the behaviors of fixed and mobile networks differ, distinct architectures for each have been discussed and proposed. This document proposes a common architecture for both mobile and fixed networking environments, using mobile IP (RFC 3775) and Network Mobility (NEMO; RFC 3963). The proposed architecture requires a modification of mobile IP and NEMO so that multiple Care-of Addresses (CoAs) can be used. In addition, multiple Home Agents (HAs) that are located in different places are required for redundancy.

## 1. Motivation

Users of small-scale networks need an easy method to improve network availability and to load balance several links. Multihoming technology is one of the solutions to improve availability. Conventional major multihoming networks use BGP, but it has some issues. Therefore, we propose a multihoming architecture using mobile IP [1] and NEMO [2] for small-scale fixed networks.

### 1.1. General Benefits of Multihoming

In a multihoming network environment, both users and network managers benefit from controlling outgoing traffic, incoming traffic, or both of them. Those benefits are described in "Goals and Benefits of Multihoming" [3]. The following is a summary of those goals and benefits:

- o Ubiquitous Access
- o Redundancy/Fault-Recovery
- o Load Sharing
- o Load Balancing
- o Bi-casting
- o Preference Settings

### 1.2. Problems to be Solved to Accomplish Multihoming

Several multihoming technologies have been proposed so far. Conventional major multihoming networks use BGP, but it has some issues, as follows.

### (1) Increasing route entries in the Internet

In the multihoming environments, each user's network needs to advertise its address block to all ISPs connected to them. If a multihomed user connects to only one ISP, the ISP can advertise routing information to aggregate them. But some multihomed users need to connect with different ISPs to be prepared for ISP failure. In this case, ISPs need to advertise routing information for multihomed users without aggregation. Therefore, the number of routing entries in the Internet is increasing one by one.

### (2) Difficulty of using multiple links efficiently

It is not easy to control incoming traffic in the case of the conventional multihoming architecture using BGP. Therefore, load balancing of connected links is difficult.

## 1.3. Using the Architecture of Mobile IP and NEMO to Solve the Problems

Basically, mobile IP (MIP) and NEMO have been proposed for mobile hosts or mobile networks; however, their architecture and protocol can be used for fixed networks and to solve the problems mentioned above. The details of the solution are described in the sections below.

Moreover, by using the architecture and the protocol of MIP and the NEMO, the cost of network operation will be decreased. For instance, in the architecture of MIP and NEMO, renumbering IP addresses when office or network equipment is relocated becomes unnecessary, as the network address prefix used by a user network in a mobile IP environment does not depend on the upstream ISP's network prefix.

## 2. Multihoming Architecture Using Mobile IP and NEMO

### 2.1. Mobile Network Includes Fixed Network

By their nature, NEMO and mobile IP must work with multihoming. This is because mobile nodes need to use multiple links to improve the availability of network connectivity since the wireless link is not always stable. Therefore, we propose that multihoming for fixed nodes (routers and hosts) uses the framework of NEMO and mobile IP.

### 2.2. Overview of Multihoming Network Architecture Using Mobile IP

Figure 1 shows the basic multihoming network architecture. In this architecture, a mobile router (MR), which is a border router of the multihomed network, sets up several tunnels between the MR and the HA by multiple-CoA registration. An HA (or a router to which the HA

belongs) advertises the user's network prefix (Prefix X in Figure 1) to ISPs via the routing protocol. If the HA has several multihomed networks (Prefix X and Y in Figure 1), they can advertise an aggregated network prefix to ISPs. Therefore, the Internet routing entries do not increase one by one when the number of multihomed users is increased.

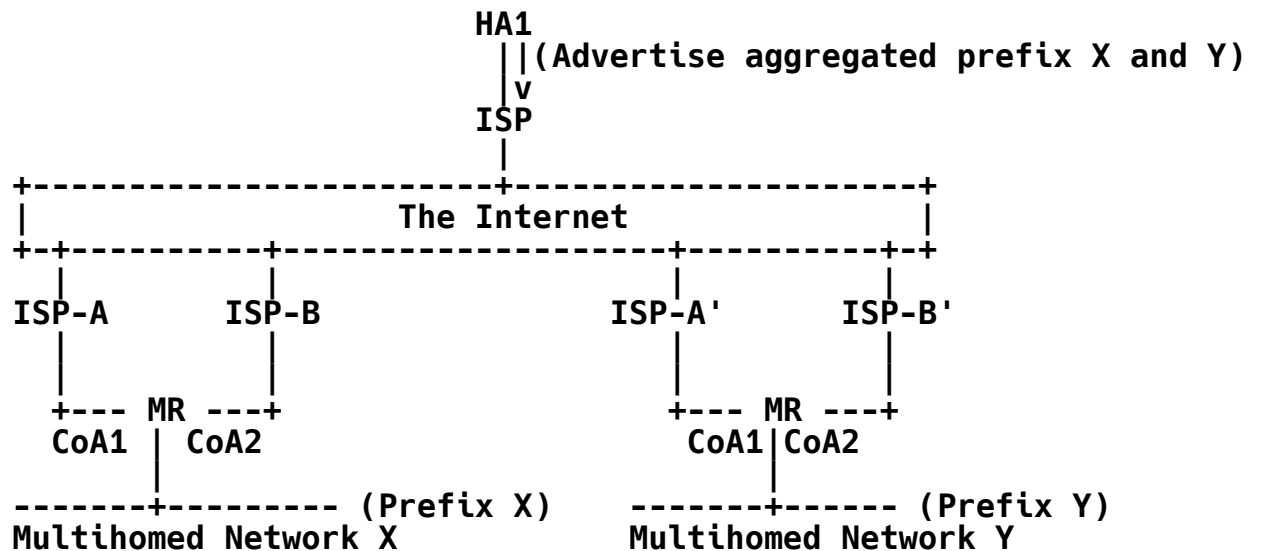


Figure 1: Advertisement of aggregated prefixes

Packets to multihomed users go to the HA, and the HA sends packets to the MR using CoA1 and CoA2. The HA selects a route in which a CoA is used. The route selection algorithm is out of scope of this document. This can improve the availability of the user network and control traffic going from the ISP to the MR. In the basic architecture, HA1 is the single point of failure. In order to improve the availability of the user network, multiple HAs are needed. This is described in Section 3.2.

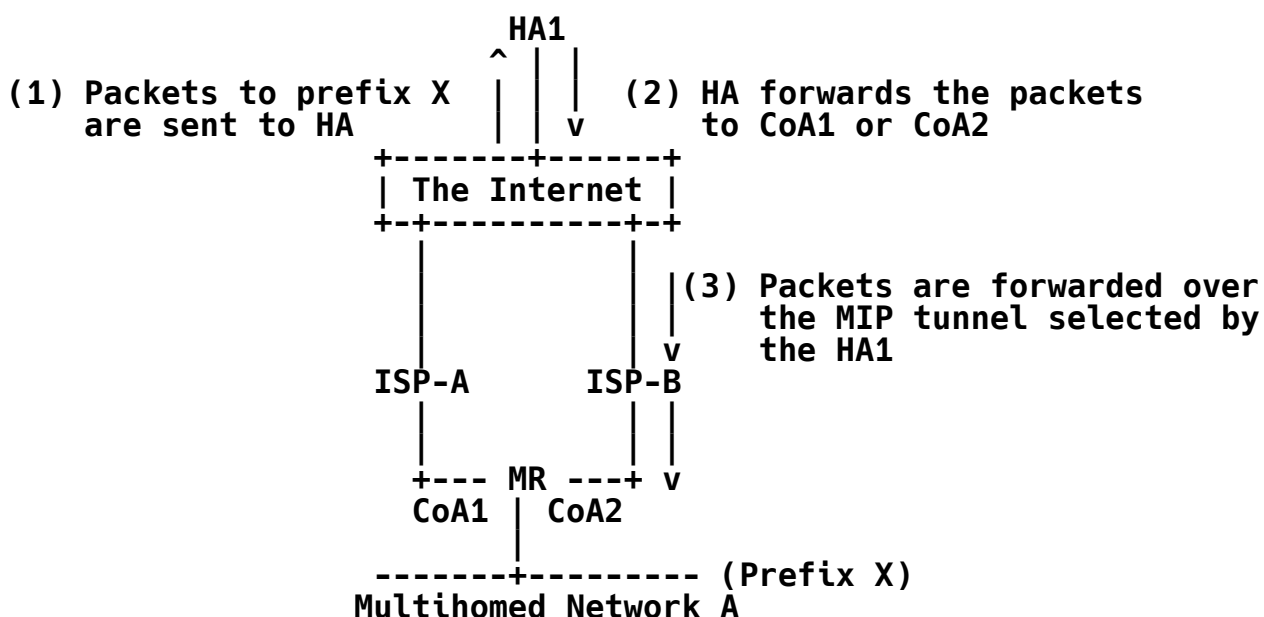


Figure 2: Packet Forwarding by HA

### 3. Requirements for Mobile IP and NEMO

#### 3.1. Multiple Care-of-Addresses (CoAs)

Multiple Care-of-Addresses are needed to improve the availability and to control incoming and outgoing traffic. The current Mobile IPv6 and the NEMO Basic Support protocol does not allow registration of more than one Care-of Address bound to a home address to the home agent. Therefore, [4] proposes to extend MIP6 and NEMO Basic Support to allow multiple Care-of Address registrations for the particular home address.

#### 3.2. Multiple Home Agents

Multiple Home Agents should be geographically distributed across the Internet to improve service availability and for the load balancing of the HA. When all the networks that have HA advertise the same network prefix to their adjacent router/network, the traffic is automatically routed to the nearest Home Agent from the viewpoint of routing protocol topology. This operation has already been proven to work in the area of Web server applications, such as CDN (Contents Delivery Network), with the Interior Gateway Protocol (IGP) and Exterior Gateway Protocol (EGP).

In order to operate multiple HAs, all HAs must have the same information such as binding information. This synchronizes the databases among the HAs. The HAHA protocol [5] introduces the binding synchronization among HAs. This is the same architecture as Internal BGP (IBGP). The database is synchronized by full-mesh topology. In addition, in order to simplify operation of the HA, the database is synchronized using star topology. This is analogous to the IBGP route reflector.

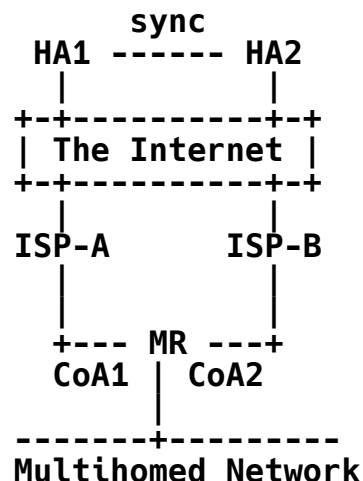


Figure 3: Architecture with HA Redundancy

## 4. Discussion on the Mailing List

### 4.1. Why the Proposed Architecture Uses NEMO Protocols

The multihomed architecture proposed in this document is basically the same as the architecture of NEMO. Furthermore, NEMO protocols meet the requirements of the proposed architecture in this document, which are:

- o The protocol can be used by the MR to send information such as the CoA, Home Address (HoA), and Binding Unique Identifier (BID) [4] to the HA.
- o The protocol can establish multiple tunnels between the MR and HA.
- o The protocol supports multiple HAs and can synchronize Binding Caches among multiple HAs.

The proposed multihomed architecture uses NEMO protocols as one of the applications of NEMO. Needless to say, using the NEMO protocol is one of the solutions to accomplish the proposed multihome

architecture. Another solution is to propose a new protocol just like NEMO. Nevertheless, such a protocol would have functions just like those of NEMO.

#### 4.2. Route Announcement from Geographically Distributed Multiple HAs

In the proposed architecture, the xSP (Multihomed Service Provider) is introduced. The xSP is a conceptual service provider; it doesn't have to be connected to the Internet physically for all practical purposes. xSP has one or more aggregatable mobile network prefixes. xSP contracts with some ISPs that are physically connected to the Internet. The purpose of this contract is to set up some HAs in those ISPs' networks. Those HAs announce the xSP's aggregated mobile network prefixes. This means that HAs work just like border gateway routers, and this situation is the same as peering between the ISP and xSP. In this case, the origin Autonomous System (AS) announced from the HAs is the xSP.

On the other hand, a multihomed user (a small office user or home user) contracts with the xSP to acquire a mobile network prefix from the xSP. Each multihomed user has an MR and multiple L3 connectivity to the Internet via multiple ISPs, and the MR will establish multiple tunnels to the HA. Since the user's mobile network prefixes are aggregated and announced from the HA, the packets to the user's mobile network will be sent to the nearest HA depending on global routing information at that time. The HA that received such packets will forward them to the user's network over the established multiple tunnels.

This model of route announcement from multiple HAs is compatible with the conventional scalable Internet architecture, and it doesn't have scalability problems.

#### 5. Implementation and Experimentation

We have implemented and experimented with the proposed architecture. Currently, the system works well not only on our test-bed network, but on the Internet. In our experimentation, the MR has two upstream organizations (ISPs) and two Care-of Addresses for each organization. The MR uses the multiple-CoA option to register the Care-of Addresses to the HA.

## 6. Security Considerations

This document describes requirements of multiple CoAs and HAs for redundancy. It is necessary to enhance the protocols of MIP and NEMO to solve the requirements. Security considerations of these multihoming networks must be considered in a specification of each protocol.

## 7. References

### 7.1. Normative References

- [1] Johnson, D., Perkins, C., and J. Arkko, "Mobility Support in IPv6", RFC 3775, June 2004.
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### 7.2. Informative References

- [3] Ernst, T., Montavont, N., Wakikawa, R., Paik, E., Ng, C., Kuladinithi, K., and T. Noel, "Goals and Benefits of Multihoming", Work in Progress, February 2004.
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