NEMO Working Group
INTERNET DRAFT
29th July 2003

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Extended Network Mobility Support
draft-perera-nemo-extended-00.txt

Status of This Memo

Abstract

This draft proposes a solution for extended network mobility support, that is a mechanism to enable optimal routing between mobile network nodes and its correspondent nodes. The proposed scheme not only provides optimal routing for the mobility aware nodes but also maintains the benefits of mobility transparency. Our solution achieves route optimization by expecting the Mobile Router to take the role of an Access Router thereby reducing the number of external signaling messages a node behind the Mobile Router needs to perform. In order to further reduce the number of signaling messages beyond the scope of the mobile network we further propose the Mobile Router to play the role of an Home Agent for NEMO-enabled nodes.

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1. Introduction

The basic NEMO protocol [1] provides session continuity to all the nodes in the mobile network. This is achieved by creating a bidirectional tunnel between the Mobile Router and its Home Agent. Although this is achieved while providing complete mobility transparency to the nodes within the network, the solution forces all datagrams for a mobile node to be routed through the Home Agent. Our solution proposes a mechanism in order to overcome this indirect routing and provide route optimization for all MIPv6-enabled nodes of a mobile network.

In MIPv6 [2] route optimization provide a means for mobile nodes to send their current mobility bindings, in particular, the care-of address to the correspondent nodes, enabling direct communication. It is evident that in order for a mobile node to perform route optimization, it should be aware of its current location.
If we were to provide network mobility transparency to all nodes within the mobile network, as the mobile nodes within the mobile network are unaware of their current location, would need to depend on the Mobile Router to deal with all mobility management issues including route optimization. We advocate on not adhering to the design goal of network mobility transparency when providing extended mobility support. We believe that allowing a mobile node to handle sending Binding Updates to its correspondent nodes is a much secure task than depending on another node to perform this task. Our scheme preserves benefits of mobility transparency when providing optimal routing for MIPv6-enabled nodes. This is achieved by extending the Mobile Router's operations, in order to limit the signaling that a mobile network node needs to perform beyond the scope of the mobile network to a minimum.

Although our solution would only support MIPv6-enabled nodes in optimal routing our solution does not inhibit in anyway the correct operation of the NEMO basic protocol for mobility unaware nodes. Our solution is backward compatible with MIPv6 and also compatible with the solution for basic NEMO support.

2. Terminology

This document uses the mobility related terminology defined in [2], [3] and [4].
The following terms are used as defined in [2].

- Home Agent
- Home Address
- Care-of Address
- Binding Update

The following terms defined in [3] specific to network mobility are used in this draft.

- Local Mobile Node
- Local Fixed Node
- Visiting Mobile Node
- Mobile Network Node

- Correspondent Nodes

- Home Subnet Prefix

- MIPv6-enabled (MIPv6-node)

- Node behind the Mobile Router

Except for the definitions of the terms 'Mobile Router' and 'NEMO-enabled' the rest of the above terms are used as per definitions in [3]. Before presenting our extensions to the definition of a Mobile Router we state the definitions of a Home Agent [2] and Access Router [4], since our definition relies on these two terms.

Access Router -

An Access Network Router residing on the edge of an Access Network and connected to one or more Access Points. The Access Points maybe of different technology. An Access Router offers IP connectivity to Mobile Nodes, acting as a default router to the Mobile Nodes it is currently serving. The Access Router may include intelligence beyond a simple forwarding service offered by ordinary IP routers.

Home Agent -

A router on a mobile node's home link with which the mobile node has registered its current care-of address. While the mobile node is away from home, the Home Agent intercepts packets on the home link destined to the mobile node's home address, encapsulates them, and tunnels them to the mobile node's registered care-of address.

Mobile Router -

A router capable of changing its point of attachment to the network, moving from one link to another link. The Mobile Router is capable of forwarding packets between two or more interfaces, and possibly running a dynamic routing protocol modifying the state by which to do packet forwarding.

The interface of a Mobile Router attached to a link inside the mobile network is called the Ingress interface. The interface of a Mobile Router attached to the home link if the Mobile Router is at home, or attached to a foreign link if the Mobile Router is in a foreign network is called the Egress interface.

A Mobile Router acting as a gateway between an entire mobile network and the rest of the Internet has one or more Egress interface(s) and one or more Ingress interface(s). Packets forwarded upstream to the rest of the Internet are transmitted through one of the Mobile Router's Egress interfaces; packets forwarded downstream to the mobile network are transmitted through one of the Mobile Router's Ingress interfaces.

Our extension to this definition -

A router capable of playing the role of a Home Agent for the Local Mobile Nodes and Local Fixed Nodes belonging to its home network link and playing the role of an Access Router for Local Mobile Nodes, Local Fixed Nodes, Visiting Mobile Nodes.

NEMO-enabled -

A MIPv6-enabled Local Mobile Node or Local Fixed Node that is capable of dynamically reconfiguring its Home Agent to be the Mobile Router when the Mobile Network is attached to a foreign link.

The keywords "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 [].

3. Overview

This scheme provides a mechanism to enable route optimization for the mobile network nodes that are MIPv6-enabled. One might question the need for the Mobile Router's participation in the mobility management of these nodes when they are MIPv6-enabled. The reason for relying on the Mobile Router to perform certain tasks for the nodes behind it, is to preserve the benefits of mobility transparency. Consider a mobile network scenario of an aircraft with potentially many Visiting

Mobile Nodes (passengers with mobile devices), Local Fixed Nodes (fixed terminals on every seat for Internet access) and Local Mobile Nodes (mobile devices that belong to aircraft personnel). In such a scenario, as the aircraft moves each of the above mentioned devices would need to communicate with an external Access Router in order to get the prefix of the new access network. These mobile devices would need to be technologically sophisticated to communicate with external Access Routers potentially via satellite links. These devices can overcome such technical difficulties and minimize the number of signaling messages beyond the scope of the mobile network by relying on the Mobile Router to perform the tasks of an Access Router for the nodes sitting behind it.

Consider in the above aircraft scenario the need for each Local Mobile Node and Local Fixed Node having to send a separate Binding Update to their respective Home Agents. We advocate on making these nodes to be NEMO-enabled in order to avoid the need for individual Binding Updates to be sent to their Home Agents. The Mobile Router can send one Binding Update to a Home Agent on the Home network representing itself and the NEMO-enabled nodes behind it. This mechanism reduces the number of external signaling messages a NEMO-enabled node needs to perform, reduces the overall usage of bandwidth beyond the scope of the mobile network and also reduces the burden on the Home Agent residing on the home network. By requiring the Mobile Router to play the role of a Home Agent for NEMO-enabled nodes, our scheme introduces a hierarchical Home Agent structure for network mobility which is depicted in figure 1.

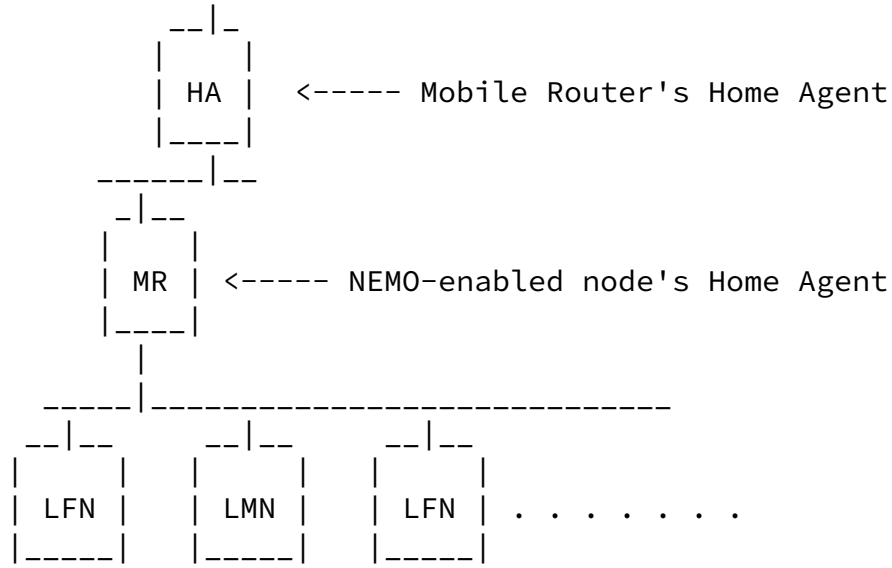


Figure 1: Hierarchical Home Agent Structure

3.1 Dual Roles of the Mobile Router

This section provides an overview of roles that the Mobile Router performs in order to preserve the benefits of hiding mobility from the nodes within the mobile network.

3.1.1 Mobile Router as an Access Router

The Mobile Router when attached to a foreign network will obtain a prefix pertaining to the new network. Once this is done the Mobile Router will act as an Access Router for the nodes behind it and will send Router Advertisement messages on its Ingress interface. Any MIPv6-enabled node sitting behind the Mobile Router will be able to use the prefix advertised by the Mobile Router and using stateless address auto configuration [5] form a care-of address for itself. Figure 2 depicts an instance of the Mobile Router playing the role of an Access Router to MIPv6-enabled Local Mobile Nodes, Local Fixed Nodes and Visiting Mobile Nodes.

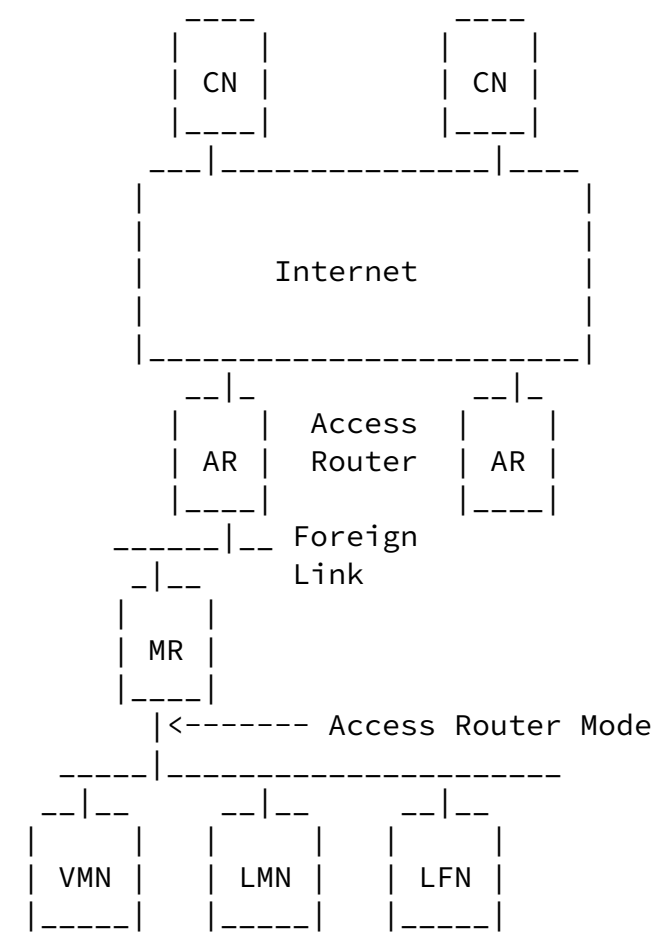
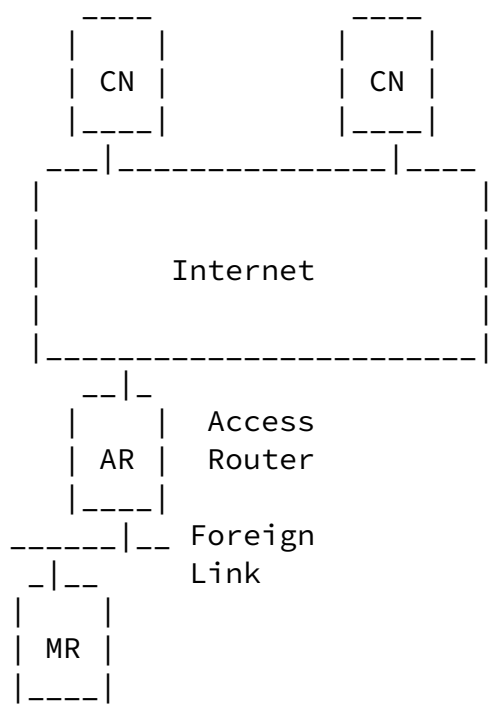


Figure 2: Instance of a Mobile Router playing the role of an Access Router

3.1.2 Mobile Router as a Home Agent

NEMO-enabled nodes sitting behind the Mobile Router can further reduce the number of external signaling messages by relying on the Mobile Router to perform the role of a Home Agent for them. Since a Home Agent is a router that resides in a mobile nodes home network we can take the Mobile Router to be a Home Agent for the Local Fixed Nodes and the Local Mobile Nodes because with respect to the Mobile Router's topology these nodes are at home. These nodes would obtain a prefix from the Access Router that is the Mobile Router and auto configure a care-of address. These operations will not differ from a standard MIPv6 mobile node operations. The NEMO-enabled nodes will register its current care-of address with the Mobile Router by dynamically configuring the Mobile Router to be their Home Agent if they belong to the Mobile Router's home network. Mobile Router would send an aggregated Binding Update to the Home Agent residing in the home network to which this mobile network belongs, reducing the usage of bandwidth. The Mobile Router on receiving any packets for the registered nodes will tunnel these packets to the registered care-of addresses of the NEMO-enabled nodes. Figure 3 depicts an instance of a Mobile Router playing the role of a Home Agent for NEMO-enabled nodes.



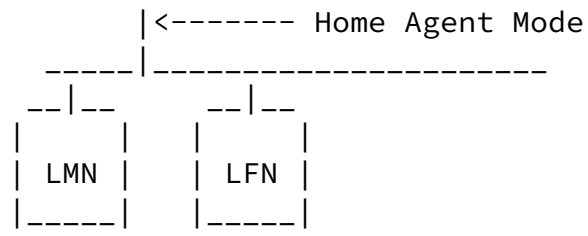


Figure 3: Mobile Router playing the role of a Home Agent

3.2 Enabling Route Optimization for the Mobile Network Nodes

This section provides an overview of the route optimization procedure for MIPv6-enabled mobile network nodes.

3.2.1 Enabling Route Optimization for the Mobile Router

The Mobile Router acting as a Mobile Node can register its care-of address with a Home Agent as well as its Correspondent Nodes. This enables direct communication between the Mobile Router and the MIPv6-enabled Correspondent Nodes. This operation does not differ from standard MIPv6 route optimization procedure for a Mobile node. If the Mobile Router is operating as a Home Agent then the Mobile Router would send a Binding Update to its Home Agent representing the nodes registered with it according to the NEMO basic protocol.

3.2.2 Enabling Route Optimization for MIPv6-enabled nodes sitting behind the Mobile Router

These nodes can obtain prefix information pertaining to the current position of the Mobile Network from the Mobile Router, now acting as an Access Router. This process will be described in detail in Section 4. Once the prefix is obtained these nodes can auto configure a care-of address and send Binding Updates to their Home Agent as well as their Correspondent Nodes. Again it is evident that route optimization is achieved by these nodes using a reduced number of signaling messages with external routers as the Mobile Router plays the role of an Access Router for the nodes within the mobile network. It is also evident that optimal routing for nodes behind the Mobile Router is achieved without requiring any changes to the standard MIPv6 operation of these nodes as well as their Correspondent Nodes.

The NEMO-enabled nodes can opt to dynamically configure the

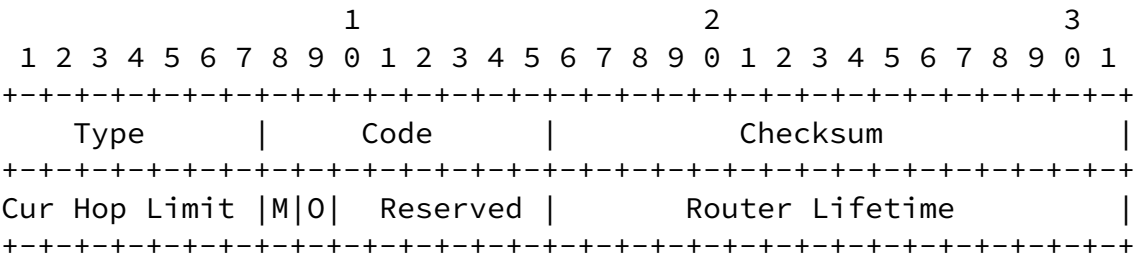
Mobile Router to be their Home Agent. This process will be explained in Section 5. In this case these nodes need only to send a Binding Update to the Mobile Router and the Mobile Router will perform the duties of a MIPv6 Home Agent for these nodes. NEMO-enabled nodes can perform route optimization as a standard MIPv6 node once they dynamically configure the Mobile Router to be their Home Agent.

4. Mobile Router Operations

In Section 4.1 we provide the details of operations a Mobile Router needs to perform when playing the role of an Access Router. This is followed by a description of operations a Mobile Router performs as a Home Agent in Section 4.2.

4.1 Mobile Router Operations as an Access Router

The Mobile Router would obtain a prefix from the Access Router in the visited network operating as a standard MIPv6 node. This is performed by running a prefix delegation protocol such as DHCPv6 [5]. (Details of this is beyond the scope of this document) After obtaining the prefix the Mobile Router would advertise this prefix to the nodes behind the Mobile Router. This can be done by using Router Advertisements as described in RFC 2461 [6] with no extensions.



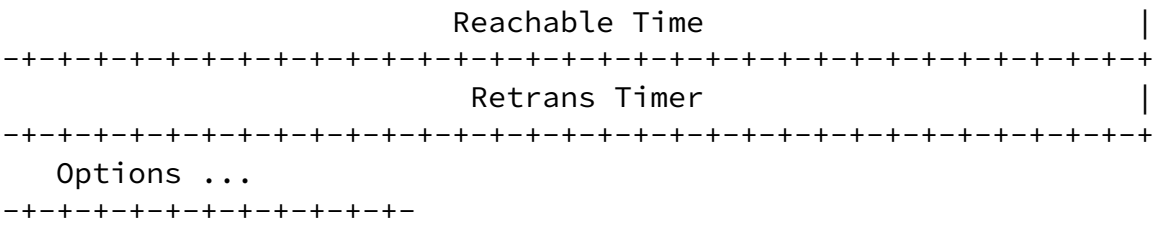


Figure 4: Router Advertisement Message Format

4.2 Mobile Router operations as a Home Agent

In this section we describe the operations a Mobile Router needs to perform when it is capable of playing the role of an Home Agent.

4.2.1 Process of Discovering the Mobile Router

If the Mobile Router is capable of playing the role of a Home Agent we propose to extend the above Router Advertisement message format by introducing a new flag bit R. This is to indicate to the NEMO-enabled nodes that the Router sending the Advertisements is a Mobile Router. The receivers which do not understand this flag MUST ignore it. We also introduce a new option named 'Home Link' to specify the Mobile Router's home link prefix. This option assists the NEMO-enabled nodes to determine whether they belong to the same link as the Mobile Router. If the prefix advertised on the 'Home Link' option matches the home address prefix of any of the NEMO-enabled nodes, these nodes can opt to reconfigure the Mobile Router as

their Home Agent.

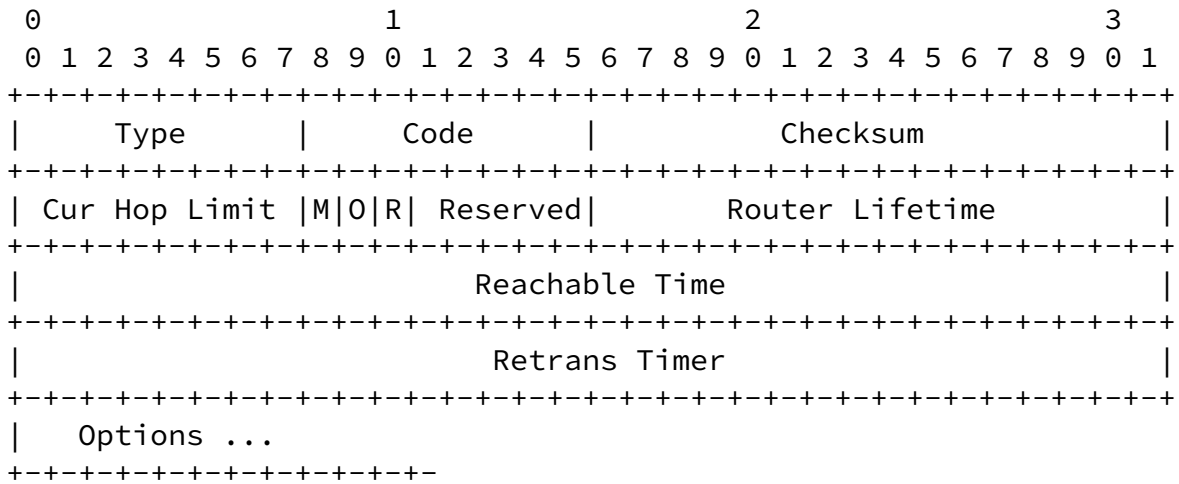


Figure 5: Router Advertisement Message Format

This format represents the following changes over that originally specified in RFC 2461 [6]:

Mobile Router Bit(R)-
The Mobile Router (R) bit MUST be set to 1 in the Router Advertisement sent by the Mobile Router while the Mobile Router is attached to a foreign link.

Reserved Field -
The Reserved Field changed from 6 bits to 5 bits.

Options -
Home Link :
This option specifies the Mobile Router's home link prefix. Receivers MUST ignore any options they do not recognize and continue processing the message [6].

4.2.2 Establishment of a Bidirectional Tunnel between the Mobile Router and the NEMO-enabled nodes

The nodes which opts to use the Mobile Router as the Home Agent would send Binding Updates to the Mobile Router. If the Binding update is valid that is if the message is from a node that belongs to the Mobile Router's home network, the Mobile Router would send a Binding Acknowledgement to the sending node. This process would establish a bidirectional tunnel between the Mobile Router and these nodes. The binding messages exchanged

here are in the same format as standard MIPv6.

4.2.3 Establishment of a Bidirectional Tunnel between the Mobile Router and its Home Agent

The Mobile Router would send a Binding Update to its Home Agent indicating that its behaving as a Mobile Router and not a Mobile Node. This can be done by employing the Binding Update format used in the NEMO basic protocol [1]. A new flag bit, Mobile Router flag(R) is used in [1]. When this flag is set the the Home Agent forwards packets destined to the mobile network to the Mobile Router. We propose to use the new mobility options defined in [1] in addition to what is defined in [2] in order to adhere with the NEMO basic protocol. These options are not described on this document, for details refer Section 4.1 in [1]. Figure 5 illustrates the new Binding Update format.

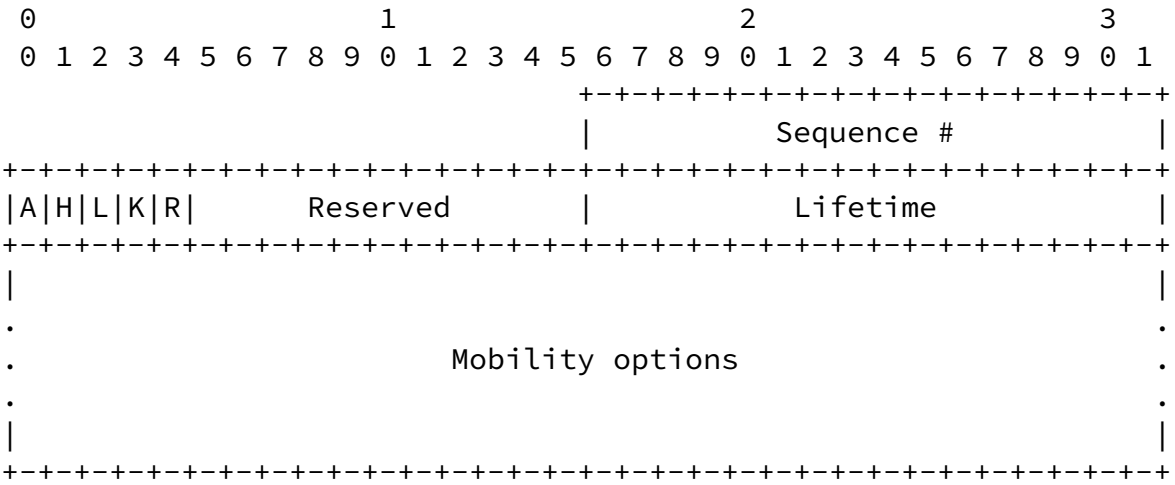


Figure 6 : Format of Binding Update with new Mobile Router Flag bit (R)

Mobile Router Flag (R)

The Mobile Router Flag is set to indicate to the Home Agent that the Binding Update is from a Mobile Router. If the flag is set to 0, the Home Agent assumes that the Mobile Router is just behaving as a Mobile Node, and should not forward packets destined for the mobile network to the Mobile Router.

5. Mobile Router's Home Agent Operations

On receiving a Binding Update with the Mobile Router flag bit (R) set the Home Agent of the mobile network would place it in its binding

cache. When a packet arrives at the home network the Home Agent would intercept the packet and would look up the binding cache with a longest prefix matching algorithm. We advocate on the use of such an algorithm at the Home Agent in order to accommodate Local Mobile Nodes being away from the home network as well as not being in the mobile network. Figure 6 below depicts such a scenario. Use of such an algorithm would also accommodate nodes which are not NEMO-enabled but are MIPv6 capable. If the Home Agent has a Binding Update for a full address or a longer prefix than the mobile network's prefix it would be routed to the care-of address on this Binding Update.

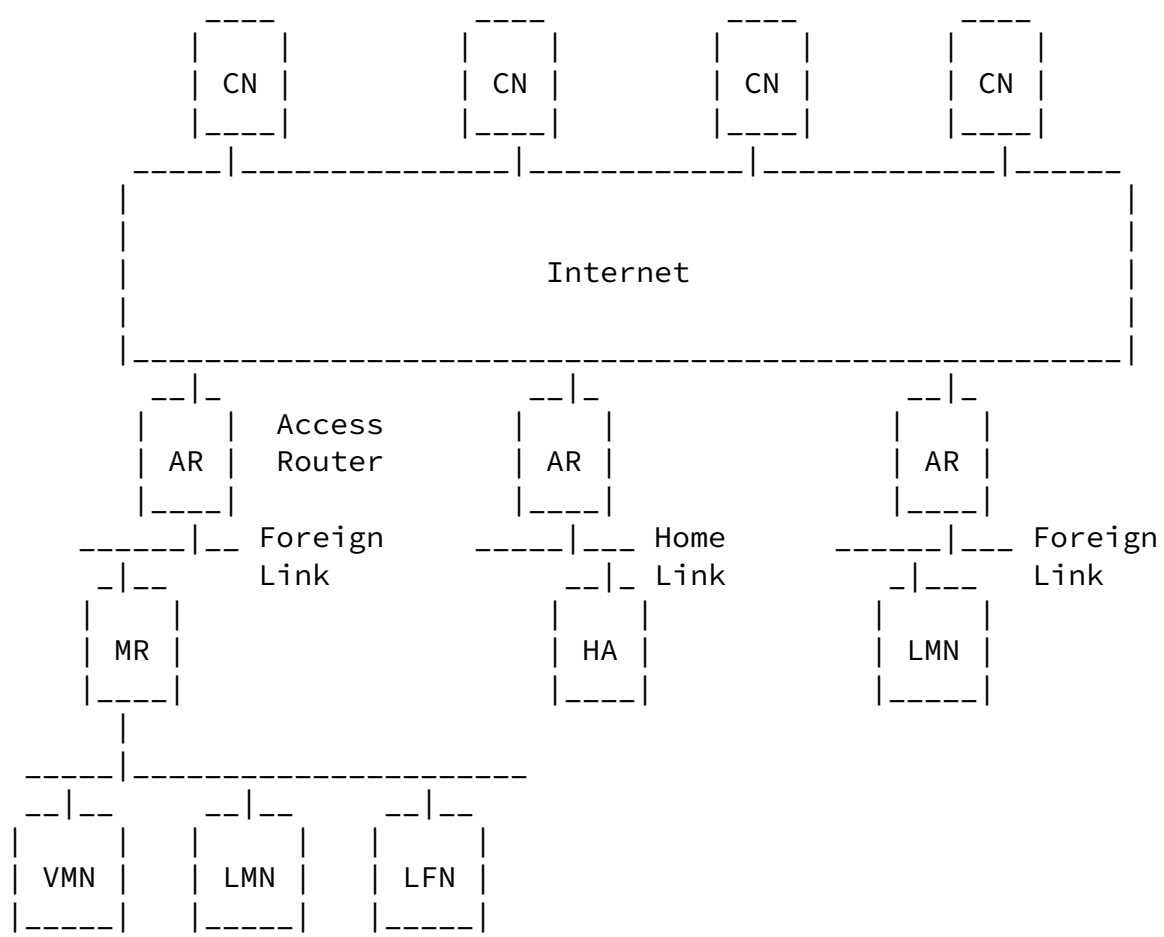


Figure 7: Local Mobile Node away from the Home Network and Mobile Network

6. Mobile Network Nodes Route Optimization Operations

6.1 MIPv6-enabled Mobile Network Nodes Operations

These nodes would obtain the new access network prefix from the Router Advertisement messages sent by the Mobile Router, which enables them to auto configure a topologically correct address. Each of them having their own care-of address can operate as standard MIPv6 nodes and enable route optimization.

6.2 Operations specific to NEMO-enabled Nodes

We define any NEMO-enabled node to be capable of dynamically reconfiguring its Home Agent to be the Mobile Router. These nodes upon receiving Router Advertisements with the Mobile Router Flag (R) set can choose to make the Mobile Router to be their Home Agent. After reconfiguring the Mobile Router to be their Home Agent these nodes need not perform any other network mobility related operations. These nodes are then able to achieve route optimization by following the standard MIPv6 protocol while needing to only communicate with a Home Agent that resides locally. Since the Mobile Router plays the role of a standard MIPv6 Home Agent for these nodes this hierarchical Home Agent structure is hidden from the NEMO-enabled nodes.

7. Security Considerations

The Mobile Network Nodes having their own care-of address can perform the return routability procedure [2] as standard MIPv6 nodes. When the Mobile Router is sending a Binding Update representing the NEMO-enabled nodes sitting behind it, it is necessary that the Home Agent verifies that these Binding Updates belong to the Mobile Network. This does not add any security consideration other than what is described in NEMO basic protocol [1].

Acknowledgements

This work was carried out through an Australian Research Council Linkage Postgraduate Research Award with Vodafone Australia Future Technologies.

References

[1] V. Devarapalli, R. Wakikawa, A. Petrescu and P. Thubert. Nemo Basic Support Protocol (work in progress), Internet Draft, IETF. draft-ietf-nemo-basic-support-00.txt, June 2003

[2] D. Johnson, C. Perkins and J. Arkko. Mobility Support in IPv6 (work in progress),Internet Draft, IETF, draft-ietf-mobileip-ipv6-22.txt. May 2003

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[4] J. Manner and M. Kojo, "Mobility Related Terminology", (work in progress), draft-ietf-seamoby-mobility-terminology.txt, Internet Draft, IETF, April 2003

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

[6] Droms, R., "Dynamic Host Configuration Protocol for IPv6 (DHCPv6)", draft-ietf-dhc-dhcpv6-28 (work in progress), November 2002.

[7] T. Narten, E. Nordmark and W. Simpson. Neighbour Discovery for IP Version 6 (IPv6), RFC 2461, IETF, December 1998

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