

## Network Mobility Support Terminology

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### Abstract

This document defines a terminology for discussing network mobility (NEMO) issues and solution requirements.

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## 1. Introduction

Network mobility support is concerned with managing the mobility of an entire network. This arises when a router connecting a network to the Internet dynamically changes its point of attachment to the fixed infrastructure, thereby causing the reachability of the entire network to be changed in relation to the fixed Internet topology. Such a network is referred to as a mobile network. Without appropriate mechanisms to support network mobility, sessions established between nodes in the mobile network and the global Internet cannot be maintained after the mobile router changes its point of attachment. As a result, existing sessions would break and connectivity to the global Internet would be lost.

This document defines the specific terminology needed to describe the problem space, the design goals [1], and the solutions for network mobility support. This terminology aims to be consistent with the usual IPv6 terminology [2] and the generic mobility-related terms already defined in the Mobility Related Terminology [3] and in the Mobile IPv6 specification [4]. Some terms introduced in this document may only be useful for defining the problem scope and functional requirements of network mobility support.

Note that the abbreviation NEMO stands for either "a Network that is MOBILE" or "Network MObility". The former (see Section 2.1) is used as a noun, e.g., "a NEMO" meaning "a mobile network". The latter (see Section 7) refers to the concept of "network mobility", as in "NEMO Basic Support", and is also the working group's name.

Section 2 introduces terms to define the architecture, while terms needed to emphasize the distinct functionalities of those architectural components are described in Section 3. Section 4, Section 5, and Section 6 describe terms pertaining to nested mobility, multihoming, and different configurations of mobile networks at home, respectively. The different types of mobility are defined in Section 7. The last section lists miscellaneous terms that do not fit into any other section.

## 2. Architectural Components

A mobile network is composed of one or more mobile IP-subnets and is viewed as a single unit. This network unit is connected to the Internet by means of one or more mobile routers (MRs). Nodes behind the MR (referred to as MNNs) primarily comprise fixed nodes (nodes unable to change their point of attachment while maintaining ongoing sessions), and possibly mobile nodes (nodes able to change their point of attachment while maintaining ongoing sessions). In most

cases, the internal structure of the mobile network will be stable (no dynamic change of the topology), but this is not always true.

Figure 1 illustrates the architectural components involved in network mobility and are defined in the following paragraphs: Mobile Router (MR), Mobile Network (NEMO), Mobile Network Node (MNN), "ingress interface", "egress interface", and Correspondent Node (CN). The other terms, "access router" (AR), "Fixed Node (FN)", "Mobile Node (MN)", "home agent" (HA), "home link", and "foreign link", are not terms specific to network mobility and thus are defined in [3].

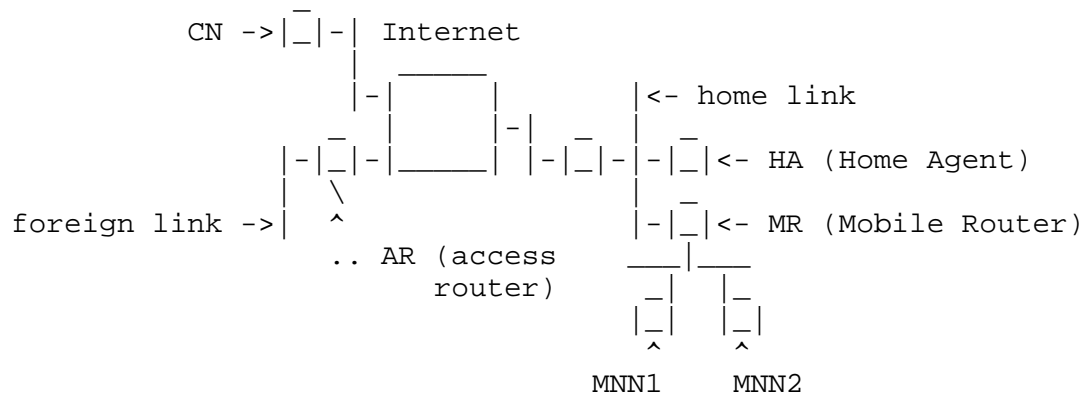


Figure 1: Mobile Network on the Home Link

Figure 2 shows a single mobile subnet. Figure 3 illustrates a larger mobile network comprising several subnets, attached to a foreign link.

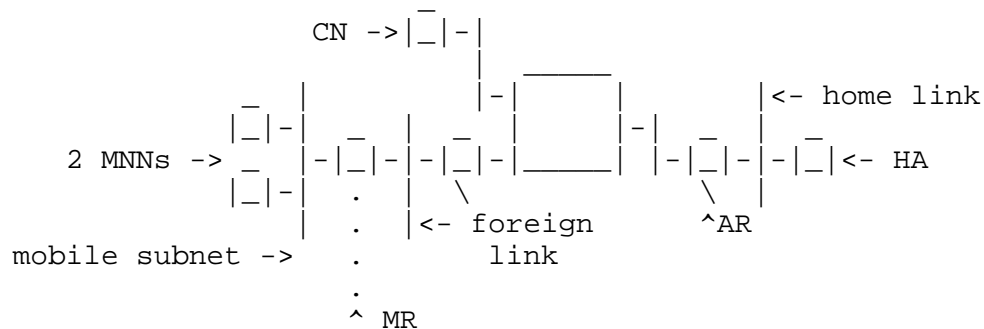
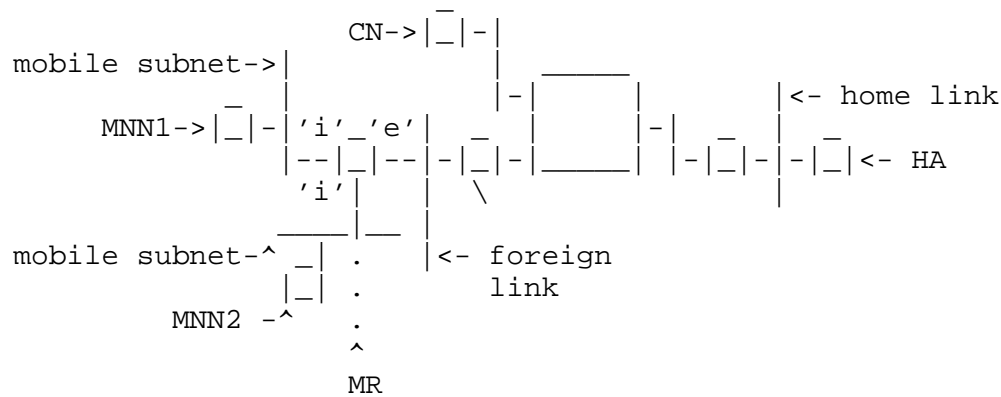


Figure 2: Single Mobile Subnet on a Foreign Link



'i': MR's ingress interface

'e': MR's egress interface

Figure 3: Larger Mobile Network Made up of 2 Mobile Subnets

At the network layer, MRs get access to the global Internet from an Access Router (AR) on a visited link. An MR maintains the Internet connectivity for the entire mobile network. A given MR has one or more egress interfaces and one or more ingress interfaces. When forwarding a packet to the Internet, the packet is transmitted upstream through one of the MR's egress interfaces to the AR; when forwarding a packet from the AR down to the mobile network, the packet is transmitted downstream through one of the MR's ingress interfaces.

## 2.1. Mobile Network (NEMO)

As defined in [3]:

An entire network, moving as a unit, which dynamically changes its point of attachment to the Internet and thus its reachability in the topology. The mobile network is composed of one or more IP-subnets and is connected to the global Internet via one or more Mobile Routers (MR). The internal configuration of the mobile network is assumed to be relatively stable with respect to the MR.

Rearrangement of the mobile network and changing the attachment point of the egress interface to the foreign link are orthogonal processes and do not affect each other.

## 2.2. Mobile Subnet

A link (subnet) that comprises, or is located within, the mobile network.

### 2.3. Mobile Router (MR)

As defined in [3]:

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

An MR acts as a gateway between an entire mobile network and the rest of the Internet, and has one or more egress interfaces and one or more ingress interfaces. Packets forwarded upstream to the rest of the Internet are transmitted through one of the MR's egress interfaces; packets forwarded downstream to the mobile network are transmitted through one of the MR's ingress interfaces.

### 2.4. Egress Interface

As defined in [3]:

The network interface of an MR attached to the home link if the MR is at home, or attached to a foreign link, if the MR is in a foreign network.

### 2.5. Ingress Interface

As defined in [3]:

The interface of an MR attached to a link inside the mobile network.

### 2.6. Mobile Network Prefix (MNP)

As defined in [3]:

A bit string that consists of some number of initial bits of an IP address which identifies the entire mobile network within the Internet topology. All nodes in a mobile network necessarily have an address containing this prefix.

### 2.7. Mobile Network Node (MNN)

As defined in [3]:

Any node (host or router) located within a mobile network, either permanently or temporarily. A Mobile Network Node may be either a fixed node (LFN) or a mobile node (either VMN or LMN).

## 2.8. Correspondent Node (CN)

Any node that is communicating with one or more MNNs. A CN could be either located within a fixed network or within a mobile network, and could be either fixed or mobile.

## 2.9. Correspondent Router (CR)

Refers to the entity that is capable of terminating a Route Optimization session on behalf of a Correspondent Node (see also NEMO Route Optimization in Section 7.5).

## 2.10. Correspondent Entity (CE)

Refers to the entity with which a Mobile Router or Mobile Network Node attempts to establish a Route Optimization session. Depending on the Route Optimization approach, the Correspondent Entity may be a Correspondent Node or Correspondent Router (see also NEMO Route Optimization in Section 7.5).

## 3. Functional Terms

Within the term Mobile Network Node (MNN), we can distinguish between Local Fixed Nodes (LFN), Visiting Mobile Nodes (VMN), and Local Mobile Nodes (LMN). The distinction is a property of how different types of nodes can move in the topology and is necessary to discuss issues related to mobility management and access control; however, it does not imply that network mobility or host mobility should be handled differently. Nodes are classified according to their function and capabilities with the rationale that nodes with different properties may have different requirements.

Figure 4 illustrates a VMN changing its point of attachment from its home link located outside the mobile network to within a mobile network. The figure also illustrates an LMN changing its point of attachment within the mobile network.

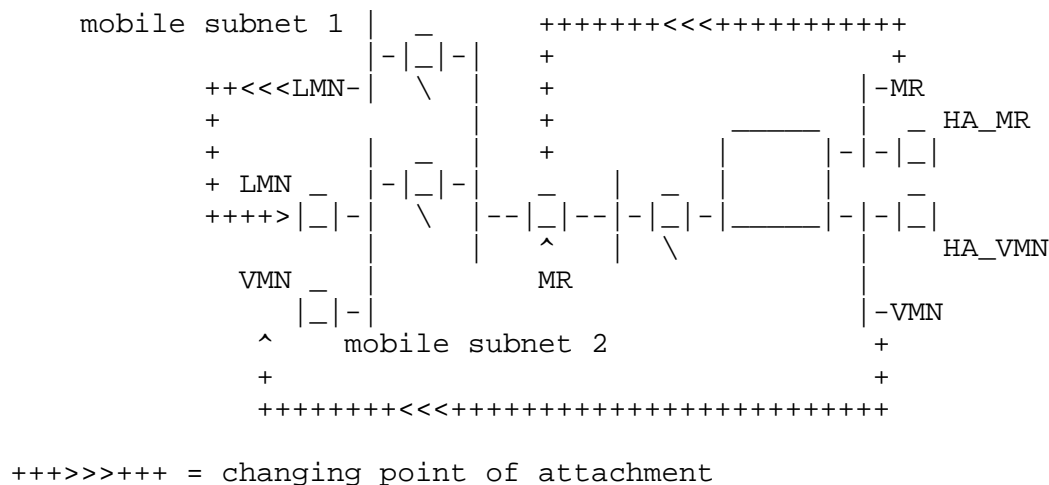


Figure 4: LFN vs LMM vs VMN

In a typical-use case of NEMO Basic Support [5], only the MR and the HA are NEMO-enabled. LFNs are not MIPv6-enabled nor NEMO-enabled. On the other hand, a VMN or an LMN acting as a mobile router may be NEMO-enabled, whereas a VMN or an LMN acting as a mobile node may be MIPv6-enabled.

For NEMO Extended Support, details of the capabilities are not yet known at the time of this writing, but NEMO-enabled nodes may be expected to implement some sort of Route Optimization.

### 3.1. Local Fixed Node (LFN)

A fixed node (FN), either a host or a router, that belongs to the mobile network and is unable to change its point of attachment while maintaining ongoing sessions. Its address is taken from an MNP.

### 3.2. Visiting Mobile Node (VMN)

Either a mobile node (MN) or a mobile router (MR), assigned to a home link that doesn't belong to the mobile network and that is able to change its point of attachment while maintaining ongoing sessions. A VMN that is temporarily attached to a mobile subnet (used as a foreign link) obtains an address on that subnet (i.e., the address is taken from an MNP).



### 3.3. Local Mobile Node (LMN)

Either a mobile node (MN) or a mobile router (MR), assigned to a home link belonging to the mobile network and which is able to change its point of attachment while maintaining ongoing sessions. Its address is taken from an MNP.

### 3.4. NEMO-Enabled Node (NEMO-Node)

A node that has been extended with network mobility support capabilities as described in NEMO specifications.

### 3.5. MIPv6-Enabled Node (MIPv6-Node)

A node that has been extended with host mobility support capabilities as defined in the Mobile IPv6 specification [4].

## 4. Nested Mobility Terms

Nested mobility occurs when there is more than one level of mobility, i.e., when a mobile network acts as an access network and allows visiting nodes to attach to it. There are two cases of nested mobility:

- o The attaching node is a single VMN (see Figure 4). For instance, when a passenger carrying a mobile phone gets Internet access from the public access network deployed on a bus.
- o The attaching node is an MR with nodes behind it, i.e., a mobile network (see Figure 5). For instance, when a passenger carrying a PAN gets Internet access from the public access network deployed on a bus.

For the second case, we introduce the following terms:

### 4.1. Nested Mobile Network (nested-NEMO)

A mobile network is said to be nested when a mobile network (sub-NEMO) is attached to a larger mobile network (parent-NEMO). The aggregated hierarchy of mobile networks becomes a single nested mobile network (see Figure 5).

### 4.2. Root-NEMO

The mobile network at the top of the hierarchy connecting the aggregated nested mobile networks to the Internet (see Figure 5).

#### 4.3. Parent-NEMO

The upstream mobile network providing Internet access to another mobile network further down the hierarchy (see Figure 5).

#### 4.4. Sub-NEMO

The downstream mobile network attached to another mobile network up in the hierarchy. It becomes subservient of the parent-NEMO. The sub-NEMO is getting Internet access through the parent-NEMO and does not provide Internet access to the parent-NEMO (see Figure 5).

#### 4.5. Root-MR

The MR(s) of the root-NEMO used to connect the nested mobile network to the fixed Internet (see Figure 5).

#### 4.6. Parent-MR

The MR(s) of the parent-NEMO.

#### 4.7. Sub-MR

The MR(s) of the sub-NEMO, which is connected to a parent-NEMO

#### 4.8. Depth

In a nested NEMO, indicates the number of sub-MRs a packet has to cross between a MNN and the root-MR.

A MNN in the root-NEMO is at depth 1. If there are multiple root-NEMOs, a different depth is computed from each root-MR.

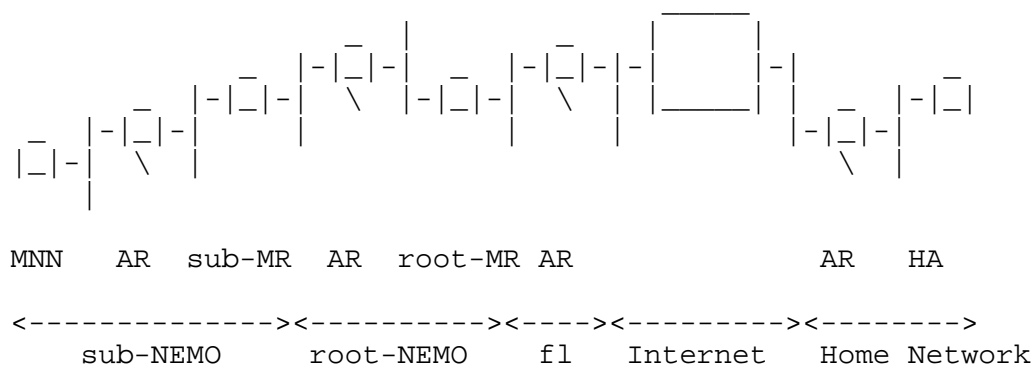


Figure 5: Nested Mobility: a sub-NEMO attached to a larger mobile network

## 5. Multihoming Terms

Multihoming, as currently defined by the IETF, covers site-multihoming [9] and host multihoming. We enlarge this terminology to include "multihomed mobile router" and "multihomed mobile network". The specific configurations and issues pertaining to multihomed mobile networks are covered in [10].

### 5.1. Multihomed Host or MNN

A host (e.g., an MNN) is multihomed when it has several addresses to choose between, i.e., in the following cases when it is:

- o Multi-prefixed: multiple prefixes are advertised on the link(s) to which the host is attached, or
- o Multi-interfaced: the host has multiple interfaces to choose from, on or not on the same link.

### 5.2. Multihomed Mobile Router

From the definition of a multihomed host, it follows that a mobile router is multihomed when it has several addresses to choose between, i.e., in the following cases when the MR is:

- o Multi-prefixed: multiple prefixes are advertised on the link(s) to which an MR's egress interface is attached, or
- o Multi-interfaced: the MR has multiple egress interfaces to choose between, on or not on the same link (see Figure 6).

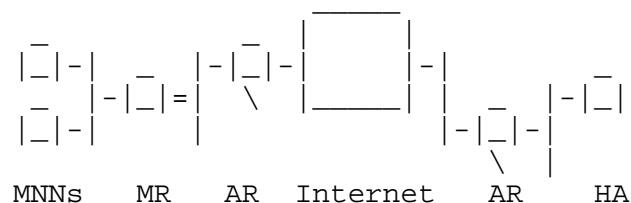


Figure 6: Multihoming: MR with multiple E-faces

### 5.3. Multihomed Mobile Network (multihomed-NEMO)

A mobile network is multihomed when a MR is multihomed or there are multiple MRs to choose between (see the corresponding analysis in [10]).

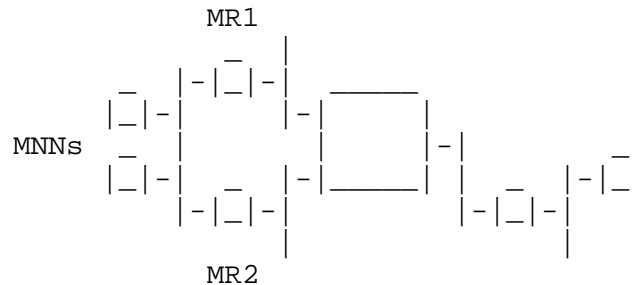


Figure 7: Multihoming: NEMO with Multiple MRs

### 5.4. Nested Multihomed Mobile Network

A nested mobile network is multihomed when either a root-MR is multihomed or there are multiple root-MRs to choose between.

### 5.5. Split-NEMO

Split-NEMO refers to the case where a mobile network becomes two or more independent mobile networks due to the separation of Mobile Routers that are handling the same MNP (or MNPs) in the original mobile network before the separation.

### 5.6. Illustration

Figure 6 and Figure 7 show two examples of multihomed mobile networks. Figure 8 shows two independent mobile networks. NEMO-1 is single-homed to the Internet through MR1. NEMO-2 is multihomed to the Internet through MR2a and MR2b. Both mobile networks offer access to visiting nodes and networks through an AR.

Let's consider the two following nested scenarios in Figure 8:

Scenario 1: What happens when MR2a's egress interface is attached to AR1?

- \* NEMO-2 becomes subservient to NEMO-1

- \* NEMO-1 becomes the parent-NEMO to NEMO-2 and the root-NEMO for the aggregated nested mobile network
- \* NEMO-2 becomes the sub-NEMO
- \* MR1 is the root-MR for the aggregated nested mobile network
- \* MR2a is a sub-MR in the aggregated nested mobile network
- \* NEMO-2 is still multihomed to the Internet through AR1 and ARz
- \* The aggregated nested mobile network is not multihomed, since NEMO-2 cannot be used as a transit network for NEMO-1

Scenario 2: What happens when MR1's egress interface is attached to AR2?

- \* NEMO-1 becomes subservient to NEMO-2
- \* NEMO-1 becomes the sub-NEMO
- \* NEMO-2 becomes the parent\_NEMO to NEMO-1 and also the root-NEMO for the aggregated nested mobile network
- \* MR2a and MR2b are both root-MRs for the aggregated nested mobile network
- \* MR1 is a sub-MR in the aggregated nested mobile network
- \* NEMO-1 is not multihomed
- \* The aggregated nested mobile network is multihomed

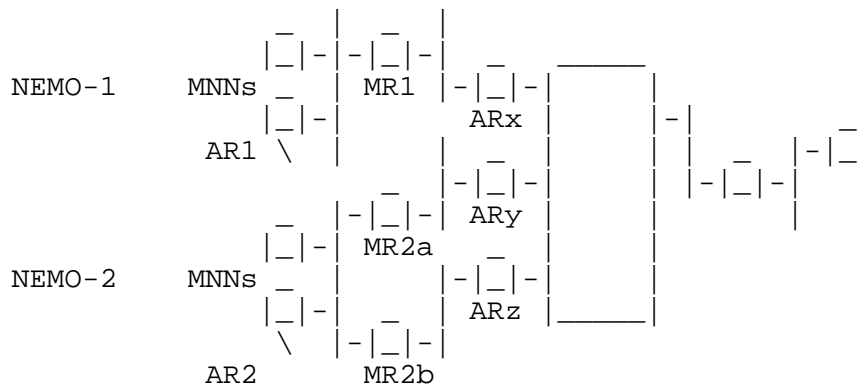


Figure 8: Nested Multihomed NEMO

## 6. Home Network Model Terms

The terms in this section are useful to describe the possible configurations of mobile networks at the home. For a better understanding of the definitions, the reader is recommended to read [6], where such configurations are detailed.

### 6.1. Home Link

The link attached to the interface at the Home Agent on which the Home Prefix is configured. The interface can be a virtual interface, in which case the Home Link is a Virtual Home Link.

### 6.2. Home Network

The Network formed by the application of the Home Prefix to the Home Link. With NEMO, the concept of Home Network is extended as explained below.

### 6.3. Home Address

With Mobile IPv6, a Home Address is derived from the Home Network prefix. This is generalized in NEMO with some limitations: A Home Address can be derived either from the Home Network or from one of the Mobile Router's MNPs.

### 6.4. Mobile Home Network

A Mobile Network (NEMO) that is also a Home Network. The MR, or one of the MR(s), that owns the MNP may act as the Home Agent for the mobile nodes in the Mobile Home Network.

### 6.5. Distributed Home Network

A Distributed Home Network is a Home Network that is distributed geographically between sites. The aggregated Home Prefix is partitioned between the sites and advertised by all sites.

This aggregated Home Prefix can be further aggregated within a service provider network or between service providers, to form a prefix that is announced into the Internet by the service provider(s) from multiple points.

The sites may be connected using a mesh of private links and tunnels. A routing protocol is used within and between sites to exchange routes to the subnets associated to the sites and, eventually, to Mobile Routers registered off-site.

## 6.6. Mobile Aggregated Prefix

An aggregation of Mobile Network Prefixes.

## 6.7. Aggregated Home Network

The Home Network associated with a Mobile Aggregated Prefix. This aggregation is advertised as a subnet on the Home Link, and thus used as the Home Network for NEMO purposes.

## 6.8. Extended Home Network

The network associated with the aggregation of one or more Home Network(s) and Mobile Network(s). As opposed to the Mobile IPv6 Home Network that is a subnet, the Extended Home Network is an aggregation and is further subnetted.

## 6.9. Virtual Home Network

An aggregation of Mobile Network Prefixes that is in turn advertised as the Home Link Prefix. The Extended Home Network and the Aggregated Home Network can be configured as Virtual Home Network.

# 7. Mobility Support Terms

## 7.1. Host Mobility Support

Host Mobility Support is a mechanism that maintains session continuity between mobile nodes and their correspondents upon the mobile host's change of point of attachment. It can be achieved using Mobile IPv6 or other mobility support mechanisms.

## 7.2. Network Mobility Support (NEMO Support)

Network Mobility Support is a mechanism that maintains session continuity between mobile network nodes and their correspondents upon a mobile router's change of point of attachment. Solutions for this problem are classified into NEMO Basic Support, and NEMO Extended Support.

## 7.3. NEMO Basic Support

NEMO Basic Support is a solution to preserve session continuity by means of bidirectional tunneling between MRs and their HAs, much like what is done with Mobile IPv6 [4] for mobile nodes when Routing Optimization is not used. Only the HA and the MR are NEMO-enabled. RFC 3963 [5] is the solution specified by the NEMO Working Group for NEMO Basic Support.

#### 7.4. NEMO Extended Support

NEMO Extended support is to provide performance optimizations, including routing optimization between arbitrary MNNs and CNS.

#### 7.5. NEMO Routing Optimization (NEMO RO)

The term "Route Optimization" is accepted in a broader sense than already defined for IPv6 Host Mobility in [4] to loosely refer to any approach that optimizes the transmission of packets between a Mobile Network Node and a Correspondent Node.

For more information about NEMO Route Optimization in the NEMO context, see the problem statement [7] and the solution space analysis [8].

#### 7.6. MRHA Tunnel

The bidirectional tunnel between a Mobile Router and its Home Agent.

#### 7.7. Pinball Route

A pinball route refers to the non-direct path taken by packets, which are routed via one or more Home Agents, as they transit between a Mobile Network Node and a Correspondent Node.

A packet following a pinball route would appear like a ball bouncing off one or more Home Agents before reaching its final destination.

### 8. Security Considerations

As this document only provides terminology and describes neither a protocol, procedure, or an implementation, there are no security considerations associated with it.

### 9. Acknowledgments

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