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Network Mobility Support Terminology
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Status of This Memo

Abstract

This document proposes a terminology for defining the problem faced by network mobility. Network mobility is concerned with situations where an entire network changes its point of attachment to the Internet and thus its reachability in the topology. We shall refer to such a network as a mobile network. Network mobility support is to maintain session continuity between nodes in the mobile network and nodes in the global Internet.

Contents

1. Introduction

   A mobile network is an entire network, moving as a unit, which
   changes its point of attachment to the Internet and thus its
   reachability in the topology. A mobile network may be composed by one
   or more IP-subnets and is connected to the global Internet via one or
   more Mobile Routers (MR). Nodes behind the MR primarily comprise
   fixed nodes (nodes unable to change their point of attachment while
   maintaining ongoing sessions), and additionally mobile nodes (nodes
   able to change their point of attachment while maintaining ongoing
   sessions). The internal configuration of the mobile network is
   assumed to be relatively stable with respect to the MR.

   If network mobility is not explicitly supported by some mechanisms
   once a MR changes its point of attachment, existing sessions between
   CNs and nodes behind the MR are broken, and connectivity to the
   global Internet is lost. In addition, fixed nodes behind the MR may
   experiment dog-leg routing, whereas multiple levels of mobility may
   cause multiple dog-leg routing. Traditional work on mobility support
   as conducted in the Mobile IP working group is to provide continuous
   Internet connectivity to mobile hosts only (host mobility support)
   and are unable to support network mobility. It is thus proposed to
   create a NEMO working group that would specify solutions for network
   mobility support (the proposed name for the working group was renamed
   from MONET to NEMO).

Cases of mobile networks include networks attached to people
(Personal Area Network or PAN, i.e. a network composed by all
Internet appliances carried by people, like a PDA, a mobile phone, a
digital camera, a laptop, etc.) and networks of sensors deployed in
aircrafts, boats, busses, cars, trains, etc. An airline company that
provides permanent on-board Internet access is an example of a mobile
network. This allows passengers to use their laptops (this scenario
is mentioned in [Tanenbaum96] under section 1.2.4 and section 5.5.8;
[Perkins98] under section 5.12; [Solomon98] under section 11.2; and
[RFC2002] section 4.5), PDA, or mobile phone to connect to remote
hosts, download music or video, browse the web. Passengers could
themselves carry a network with them (a PAN). At the same time, air
control traffic could be exchanged between the aircraft and air
traffic control stations (this scenario has already been investigated
by Eurocontrol, the European Organization for the safety of air
navigation, [Quinot98]). During a transatlantic flight, the aircraft
changes its point of attachment to the Internet and may be reachable
by distinct Internet Service Providers (ISPs). Over the oceans, the
aircraft gets connected to the Internet through a geostationary
satellite; over the ground, it's through a radio link. Handoffs do
typically not occur very often (a radio link may cover 400-500
kilometers). Another similar scenario mentioning ships and aircrafts
can be found in [RFC1726, section 5.15]. Similarly, a bus, the
metropolitan public transport, or the taxi company could allow
passengers to connect their PAN to the Internet via the embarked
network, therefore ensuring, while on-board, an alternative to the
metropolitan cellular network, in terms of price or available
bandwidth, access control, etc. Meanwhile, a number of Internet
appliances deployed in the mobile network are used to collect traffic
and navigation data from the Internet while sensors within the mobile
network collect and transmit to the Internet live information, like
the current number of passengers, expected time to arrival, the
amount of petrol left in the tank, etc. For a number of reasons
(network management, security, performance,...), it is desirable to
interconnect the Internet appliances deployed in cars, trains, busses
by means of, for instance, an Ethernet cable, instead of connecting
them individually and directly to the Internet, therefore exhibiting
the need to displace an entire network.

To describe such kind of scenarios, we need to agree on a
terminology. However, there is presently no existing terminology to
define the issues, goals, architecture elements, problems and
requirements pertaining to the scenarios outlined here above, but one
is needed. It is therefore the object of this document to propose
such a new terminology and to highlight some characteristics of
mobile networks.

The material presented in this document is based on [Ernst01] and on

our former internet-draft that was submitted in July 2001 [OLD-draft] for the consideration of the Mobile IP Working Group. In addition to the present terminology, this former draft was also presenting a set of requirements and issues as an attempt to clarify the problem caused by network mobility. We decided to split this former document in two because requirements are more subject to discussion and disagreements than the terminology on which we must agree on to base our discussion. Our proposed requirements can therefore now be found in [REQUIREMENTS-1]. Additional requirements may be found in [REQUIREMENTS-2] and [REQUIREMENTS-3]. A comprehensive description of the problem and issues posed by network mobility is discussed in [SCOPE]. More information may be found on the MONET web page [WEB-MONET].

2. Terminology

The new terms we introduce comply with the terminology already defined in the IPv6 [RFC2460] and Mobile IPv6 [MIPv6] specifications. Although our terminology is primarily targeted toward IPv6, it is not necessarily limited to it. This list comprises terms that appeared on the mailing list for the purpose of explaining the problem scope. Some of them may only be useful for the purpose of defining the problem scope and functional requirements of network mobility support. Definitions will have to be refined once we agree on the problem scope.

The first section introduces terms to define the architecture components; the second introduces terms to discuss nested mobility; the last section introduces a number of other terms useful to discuss requirements.

2.1. Architecture Components

Mobile Network

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 connected to the global Internet via one or more mobile router(s) (MR). The internal configuration of the mobile network is assumed to be relatively stable with respect to the MR and is not a matter of concern.

Mobile Network Node (MNN)

Any host or router located within the mobile network, either permanently or temporarily. A MNN could be any of a MR, LFN, VMN, or LMN. The distinction between LFN, LMN and VMN is necessary to

discuss issues related to mobility management and access control,
but does not preclude that mobility should be handled differently.
Nodes are classified according to their function and capabilities.

```
              ____
             |    |
             | CN |
             |____|
          ___|_____
         |                      |
         |                      |
         |      Internet        |
         |                      |
         |_____|
          __|_          __|_
         |    |  Access |    |
         | AR |  Router | AR |
         |____|         |____|
       _____|__ foreign  __|_____ home
              link               __|_      link
                                |    |
                                | MR |  Mobile Router
                                |____|
                        _____|_____  internal
                       __|__      __|__     link
                      |    |    |    |
                      | MNN |   | MNN |  Mobile Network Nodes
                      |_____|   |_____|
```
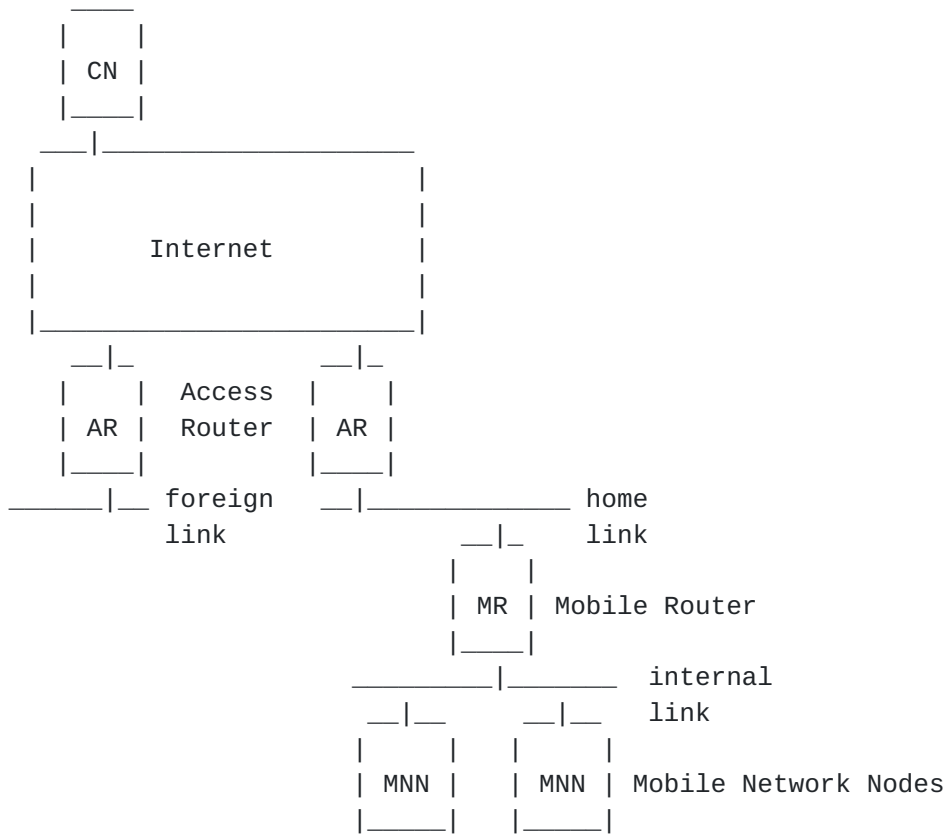
Figure 1: Terminology

Mobile Router (MR)

   A router which changes its point of attachment to the Internet and
   which acts as a gateway to route packets between the mobile
   network and the rest of the Internet. The MR is NEMO-enabled and
   maintains the Internet connectivity for the mobile network. It has
   at least two interfaces, an egress interface, and an ingress
   interface. When transmitting a packet to the Internet (i.e.
   outside), it forwards it through the egress interface; when
   transmitting it withing the mobile network (i.e. inside), it
   forwards it through the ingress interface.

Local Fixed Node (LFN)

   A standard IPv6 node, either a host (LFH) or a router (LFR), that
   belongs to the mobile network and which has no mobility support
   capabilities at all (i.e. it isn't NEMO-enabled nor

MIPv6-enabled).

```
                      ____
                     |    |
                     | CN |
                     |____|
                 ___|_____
                |                      |
                |                      |
                |      Internet        |
                |                      |
                |_____|
                 __|_            __|_
                |    |  Access  |    |
                | AR |  Router  | AR |
                |____|          |____|
                 __|_            _____|_____ home
                |    |               _|__    link
                | MN ]              |  |    |
                |____|              |__| MR | Mobile Router
                                    |  |____|
                                    |   __|_____ internal
                                    |  __|__    __|__   link 1
                       _____        | |    |   |    |
                      |     |__|    | LFN |   | LMN |
                      | LFN |   |   |_____|   |_____|
                      |_____|   |
                                | internal
                                  link 2
```
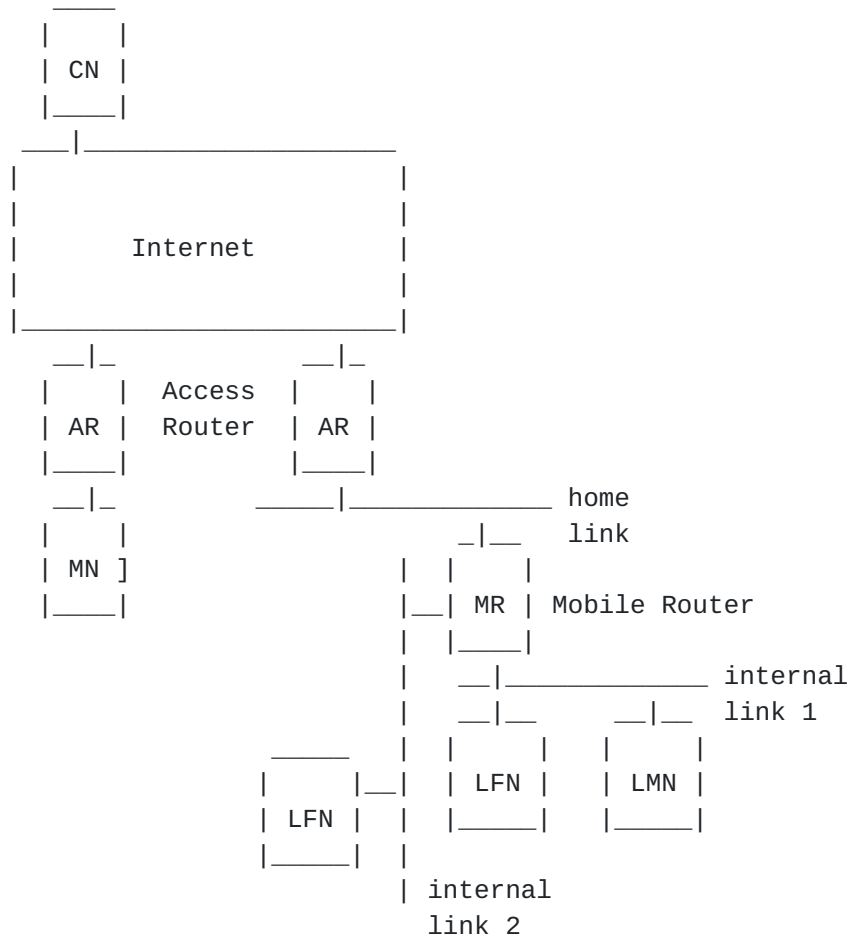
                   Figure 2: Larger Mobile Network with 2 subnets

   Local Mobile Node (LMN)

      A mobile node, either a host (LMH) or a router (LMR), that belongs
      to the mobile network (i.e. its home link is within the mobile
      network). It is MIPv6-enabled and may be NEMO-enabled.

   Visiting Mobile Node (VMN)

      A mobile node, either a host (VMH) or a router (VMR), that doesn't
      belong to the mobile network (i.e. its home link is not within the
      mobile network), and which gets attached to a link within the
      mobile network and obtains an address on that link. It is
      MIPv6-enabled and may be NEMO-enabled.

```
                          ____
                         |    |
                         | CN |
                         |____|
                      ___|_____
                     |                      |
                     |                      |
                     |      Internet        |
                     |                      |
                     |_____|
                       __|_           __|_
                      |    |  Access  |    |
                      | AR |  Router  | AR |
                      |____|          |____|
                       __|_            _____|_____ home
                      |    |                  _|__    link
                      | MN |                 |  |    |
                      |____|         _____   |__| MR | Mobile Router
                              |     |__|  |____|
                     |-->  | LMN |  |    __|_____ internal
                     |     |_____|  |   __|__        |    link 1
                     |      _____   |  |     |        |
                     |     |    |__|  | LFN |        |
                     |     | LFN |  |  |_____|        |
                     |     |_____|  |                 |
                     |             | internal        |
                     |               link 2          |
                     |------------------------------|
```
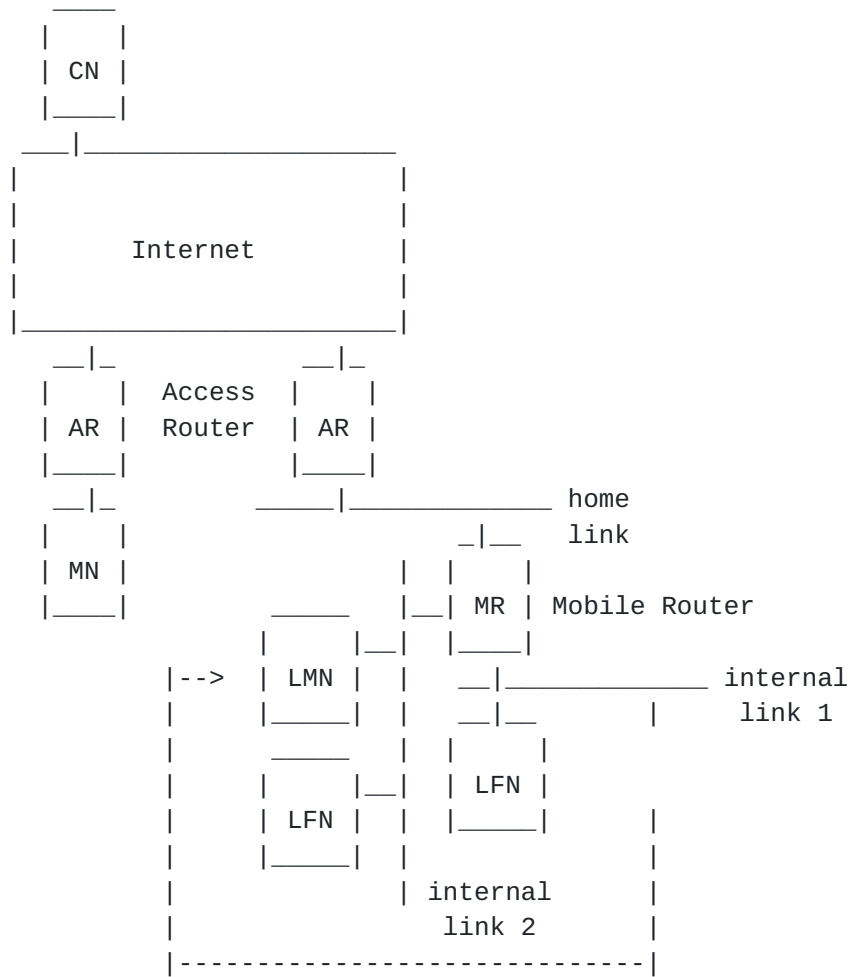
<p align="center">Figure 3: LMN changing subnet</p>

Node behind the MR

  Any MNN in a mobile network that is not a MR for this mobile
  network.

Correspondent Node (CN)

  Any node that is communicating with one or more MNNs located in
  the same mobile network. A CN could itself be located within the
  mobile network.

Access Router (AR)

  Any subsequent point of attachment of the MR at the network layer.
  Basically, a router on the home link or the foreign link.

   Home subnet prefix

      A bit string that consists of some number of initial bits of an IP
      address which identifies the MR's home link within the Internet
      topology (i.e. the IP subnet prefix corresponding to the mobile
      node's home address, as defined in [MIPv6]).

   Foreign subnet prefix

      A bit string that consists of some number of initial bits of an IP
      address which identifies the MR's foreign link within the Internet
      topology.

   Mobile Network Prefix

      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 MNNs necessarily have an address named
      after this prefix.

   Egress Interface of a MR

      The interface 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.

   Ingress Interface of a MR

      The interface attached to a link inside the mobile network. This
      interface is configured with the Mobile Network Prefix.

   The terminology is summarized in fig.1 to 3. Fig.1 shows a single
   mobile subnetwork. Fig.2. shows a larger mobile network comprising
   several subnetworks. Fig.3 illustrates a LMN changing its point of
   attachment within the mobile network.

  2.2. Nested Mobility

   We speak about nested mobility when there are more than one level of
   mobility, i.e. when a VMN gets attached to the mobile network. A MNN
   acts as an Access Router for this VMN.

   If the VMN is actually a VMR with nodes behind it, this is a mobile
   network which gets attached to a larger mobile network. The former is
   a sub-MONET, and the latter the parent-MONET. It is generally
   assumed that the sub-MONET and the parent-MONET become a single

aggregated mobile network, i.e. the sub-MONET is indeed a subservient
of the larger MONET in terms of getting address space.

The MR(s) used to directly connect the aggregated mobile network to
the fixed Internet is referred to as the Top-Level Mobile Router
(TLMR) The terms upstream-MONET, downstream-MONET, and root-MONET
have also been introduced.

```
                          _____
                         |     |
                         | CN  |
                         |_____|
                      ___|_____
                     |                      |
                     |                      |
                     |       Internet       |
                     |                      |
                     |_____|
                       __|_           __|_
                      |    |  Access  |    |
                      | AR |  Router  | AR |
                      |____|          |____|
                                  _____|_____  home
                      |                        _|__    link
                      |                       |  |   |
                      |            _____      |__| MR |  Mobile Router
                      |           |     |__|   |____|
            ----------> | VMN |   |    __|_____  internal
                      |_____|   |    __|_      __|__  link 1
                       _____    |  |      |   |     |   |
                      |     |__|  | LFN |  | LMN |
                      | LFN |  |  |_____|   |_____|
                      |_____|  |
                               | internal
                                 link 2
```
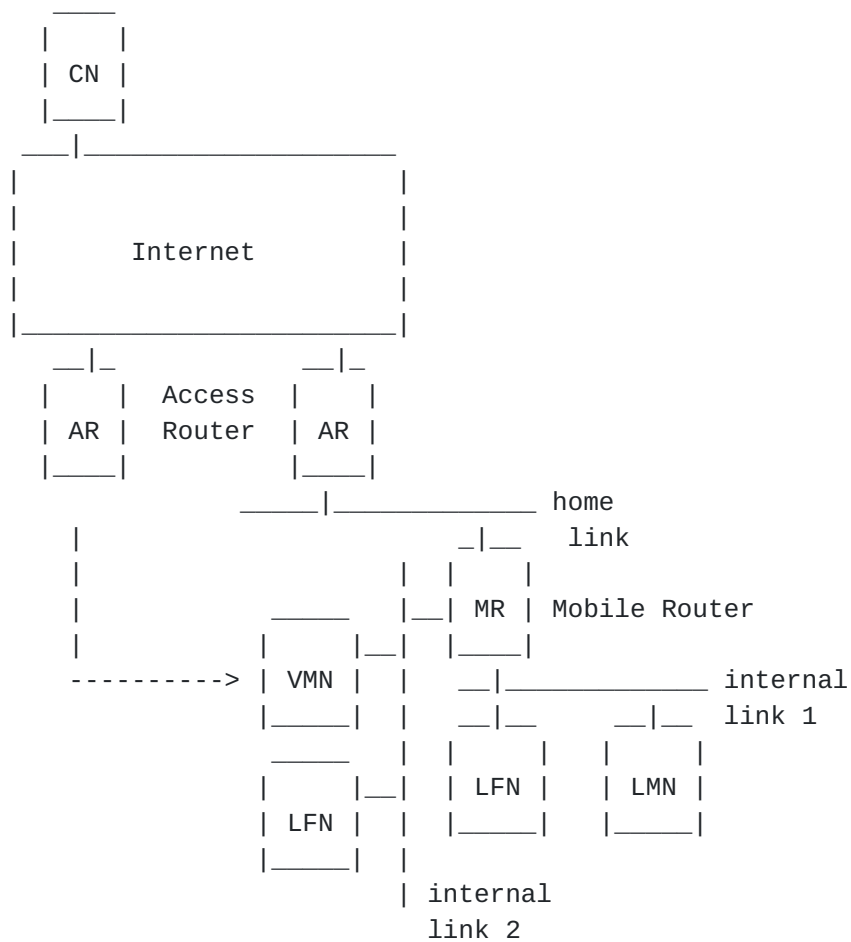
        Figure 4: Nested Mobility: single VMN that attaches to a mobile network

        As for an instance of nested mobility, when a passenger carrying a
        mobile phone (VMN) or a PAN (sub-MONET) gets Internet access from
        the public access network deployed in the bus (parent-MONET).
        Fig.4 and 5. illustrate nested mobility. In fig.4, a single VMN
        gets attached to the mobile network. In fig 5, a VMR carrying an
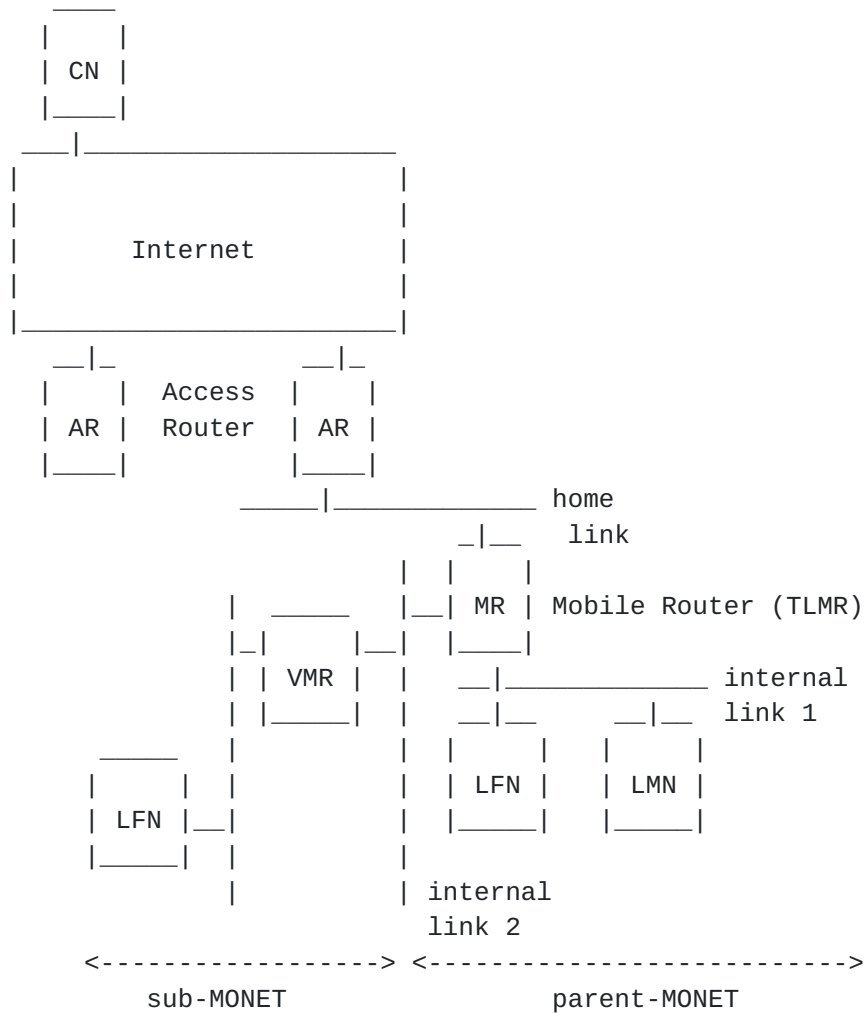   entire network, thus a sub-MONET.

```
                     ____
                    |    |
                    | CN |
                    |____|
               ___|_____
              |                     |
              |                     |
              |     Internet        |
              |                     |
              |_____|
               __|_           __|_
              |    |  Access  |    |
              | AR |  Router  | AR |
              |____|          |____|
                      _____|_____ home
                           _|__   link
                          |  |    |
              |   _____   |__| MR | Mobile Router (TLMR)
              |_|       |__| |____|
              | | VMR |  |    __|_____ internal
              | |_____|  |   _|__      __|__  link 1
        _____   |        |  |    |    |    |
       |    |   |        |  | LFN |   | LMN |
       | LFN |__|        |  |____|    |_____|
       |____|   |        |
              |          | internal
                         link 2
        <------------------> <---------------------------->
              sub-MONET              parent-MONET
        Figure 5: Nested Mobility: sub-MONET that attaches to a larger
                           mobile network
```

2.3. Miscellaneous Terms

 NEMO-enabled node

    a node that has been extended with NEtwork MObility support
    capabilities and may take special actions based on that. (Details
    of the capabilities are not known yet, but it will be based on
    enhancements to Mobile IPv6 [MIPv6] and may be implementing some
    sort of Route Optimization).

 MIPv6-enabled node

    A mobile node that implements the "MN Operation" of Mobile IPv6

   [MIPv6]. I.e. A node that only implements the "CN Operation" of
   Mobile IPv6 is NOT considered MIPv6-enabled.

Multihoming

   Multihoming, as currently defined by the IETF, covers site-
   multihoming [MULTI6] and host multihoming. Within host-
   multihoming, a host may be either:

      - multi-addressed: multiple source addresses to choose between
      on a given interface; all IPv6 nodes are multi-addressed due to
      the presence of link-local addresses on all interfaces.

      - multi-interfaced: multiple interfaces according to [RFC2460]
      definition.

      - multi-linked: just like multi-interfaced but all interfaces
      are NOT connected to the same link.

      - multi-sited: when using IPv6 site-local address and attached
      to different sites

   What is meant by a multihomed-MONET is not clear and is left for
   open discussion. It depends on the possible configurations covered
   by the revised problem scope. Future discussion will assess if a
   MR may fall in all the above described cases and if multiple MRs
   may be used to connect the mobile network to the Internet.

Local-Area Mobility

   Mobility within a single administrative domain, i.e. between
   subnetworks topologically close in the IP hierarchy. In the
   literature, and depending on the definition of ``closeness'', this
   is also termed intra-site mobility, intra-domain mobility, local
   mobility or micro-mobility. As an instance of Local-Area Mobility,
   the displacement of a node within a limited vicinity of adjacent
   subnetworks, like in a campus, that belong to the same
   organization or between ARs that belong to the same ISP.

Wide-Area Mobility

   Mobility across domain boundaries, i.e. between subnetworks
   topologically distant in the IP hierarchy. In the literature, and
   depending on the definition of ``remoteness'', this is also termed
   inter-site mobility, inter-domain mobility, or global mobility, or
   macro-mobility. As an instance of Wide-Area Mobility, displacement
   of a node between distinct ISPs or organizations, or between
   widely separated sites of a single organization.

Idle MNN

   A MNN that does not engage in any communication.

Idle Mobile Network

   A mobile network that does not engage in any communication outside
   the network may be considered as idle from the point of view of
   the Internet. This doesn't preclude that MNNs are themselves idle.
   Internal traffic between any two MNNs located in the same mobile
   network is not concerned by this statement.

3. Observations

   Structure of the mobile network

      A MR changing its point of attachment does not cause the MNNs
      behind the MR to change their own physical point of attachment.
      Thus, the internal structure of a mobile network is not modified
      as a result of the mobile network changing its point of
      attachment. MNNs may or may not notice such a displacement, but
      they must not be required to be NEMO-enabled. However, MNNs MAY
      appear to move from the point of view of an observer in the
      Internet. In addition, the internal structure of the mobile
      network is assumed to be relatively stable (no dynamic change of
      the topology).

   Mobile Router is a transit point

      All packets sent from a CN to a MNN necessarily transit through a
      MR.

   Size of the mobile network

      A mobile network may comprise one or more subnets. Its size could
      scale from a sole subnet with a few IP devices, such as in the
      case of a PAN, to a collection of subnets with hundreds of IP
      devices, such as in a train.

   Large number of CNs

      A mobile network may have a very large number of CNs. For
      instance, each passenger in a train may be considered a MNN. Each
      of them may be communicating with a few CNs. As a result, the
      total number of CNs could be several times as large as the number
      of MNNs and scale up to a few thousands.

   Sparseness of the CNs

      CNs are typically sparsely distributed in the Internet and belong
      to distinct administrative domains.

   Handoff frequency

      Mobile networks may not move with the same speed and frequency.
      For instance, a PAN connected to the Internet via a 802.11b WLAN
      (e.g. user in a shopping mall) is likely to change its point of
      attachment very frequently, while an aircraft or a boat may be
      connected to the Internet via the same satellite link for a couple
      of hours. Obviously, mobile networks may not move at all for a

large amount of time.

Dog-leg Routing

As a result of mobility, routing between a CN in the global
Internet and a mobile node may not be optimal. Packets usually
transit via the home link of the mobile node if no routing
optimization is explicitly performed. In network mobility,
multiple dog-leg routing may be introduced by nested mobility. In
this case, packets intended to a VMN may first transit by the
VMN's home link, then being rerouted to the MR's home link.

Ad-Hoc Network

An Ad-hoc network as defined in the IETF MANET Working Group is
not to be confused with a mobile network. An ad-hoc network is an
autonomous system made of mobile nodes (i.e. routers) connected by
wireless links. The routers are free to move randomly and to
organize themselves arbitrary. Topologies are highly dynamic. In a
mobile network, some routers may effectively move arbitrary, but
this not a common case. However, an Ad-hoc network connected to
the Internet and that changes its point of attachment may be
considered as a special instance of a mobile network.

Network mobility support (NEMO) and Mobile Ad-hoc Networking
(MANET) have not the same objectives. Network mobility support
aims at providing Internet reachability to nodes in the mobile
network and at maintaining session continuity after the mobile
network has changed its point of attachment in the topology. On
the other hand, MANET aims at maintaining routes between highly
dynamic nodes.

Routers in the Mobile Network

All routers in the Internet are considered to run a number of
protocols such as a routing protocol, Neighbor Discovery, ICMP,
and others. This also applies to routers in the mobile network,
including the MR.

[4](). Changes from previous draft

   - updated definition of LFN, LMN, VMN, mobile network, mobile network prefix, CN

   - added terms NEMO-enabled and MIPv6-enabled.

   - added a section (2.2) for terminology specific to nested mobility: root-MONET, parent-MONET, sub-MONET, upstream, downstream.

   - added a paragraph about multihoming

   - removed mobile IP-subnet.

   - added comments about Ad-Hoc network in [section 3]()

   - added comments about multiple dog-leg routing in [section 3]()

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