NEMO Working Group
Internet-Draft
Expires: April 25, 2005

T. Ernst
WIDE at Keio University

October 25, 2004

Network Mobility Support Goals and Requirements
draft-ietf-nemo-requirements-03

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Abstract

Network mobility arises when a router connecting an entire network to the Internet dynamically changes its point of attachment to the Internet therefrom causing the reachability of the entire network to be changed in the topology. Such kind of network is referred to as a mobile network. Without appropriate mechanisms, sessions established between nodes in the mobile network and the global Internet cannot be maintained while the mobile router changes its point of attachment. The required support mechanisms will be provided in two phases. The

first phase, referred to as NEMO Basic Support is to provide session continuity while the necessary optimizations mechanims referred to as NEMO Extended Support might be provided later. This document outlines the goals expected from network mobility support and defines the requirements that must be met by NEMO Basic Support solutions.

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1. Introduction

Network mobility support is concerned with managing the mobility of an entire network, viewed as a single unit, which changes its point of attachment to the Internet and thus its reachability in the Internet topology. Such kind of network is referred to as a mobile network and includes one or more mobile routers (MRs) which connect it to the global Internet. Nodes behind the MR(s) (MNNs) are both

fixed (LFNs) and mobile (VMNs or LMNs). In most cases, the internal structure of the mobile network will in effect be relatively stable (no dynamic change of the topology), but this is not a general assumption.

Cases of mobile networks include for instance:

- networks attached to people (Personal Area Networks or PANs): a cell-phone with one cellular interface and one Bluetooth interface together with a Bluetooth-enabled PDA constitute a very simple instance of a mobile network. The cell-phone is the mobile router while the PDA is used for web browsing or runs a personal web server.

- networks of sensors and computers deployed in vehicles: vehicles are more and more embedded with a number of processing units for safety and ease of driving reasons, as advocated by ITS (Intelligent Transportation Systems) applications.

- access networks deployed in public transportation (buses, trains, taxis, aircrafts): they provide Internet access to IP devices carried by passengers (laptop, camera, mobile phone: host mobility within network mobility or PANs: network mobility within network mobility, i.e. nested mobility).

- ad-hoc networks connected to the Internet via a MR: for instance students in a train that both need to set up an ad-hoc network among themselves and to get Internet connectivity through the MR connecting the train to the Internet.

Mobility of networks does not cause MNNs to change their own physical point of attachment, however they happen to change their topological location with respect to the global Internet. If network mobility is not explicitly supported by some mechanisms, the mobility of the MR results into MNNs losing Internet access and breaking ongoing sessions entertained between arbitrary correspondent node (CNs) in the global Internet and those MNNs located within the mobile network. In addition, the communication path between MNNs and arbitrary correspondent nodes (CN) becomes sub-optimal, whereas multiple levels of mobility will cause extremely sub-optimal routing.

The mechanisms required for handling such mobility issues are currently lacking within the IETF standards. Traditional work conducted on mobility support (particularly in the Mobile IP working group) is to provide continuous Internet connectivity and optimal routing to mobile hosts only (host mobility support) and are unable to support network mobility. The NEMO working group has therefore been set up to deal with issues specific to network mobility. The purpose of this document is thus to detail the methodology that will be followed by the NEMO working group, its goals, and to define requirements for network mobility support.

Mobility-related terms used in this document are defined in [3] whereas terms pertaining to network mobility specifically are defined in [4]. This document is structured as follows: Section 2 defines the rough objectives and methodology of the NEMO working group and we emphasize the stepwise approach the working group has decided to follow. A number of desirable design goals are listed in Section 3. Those design goals serve as guidelines to edict the requirements listed in Section 4 for basic network mobility support [2].

2. NEMO Working Group Objectives and Methodology

The primary objective of the NEMO work is to specify a solution which allows mobile network nodes (MNNs) to remain connected to the Internet and continuously reachable at all times while the mobile network they are attached to changes its point of attachment. Secondary goals of the work is to investigate the effects of network mobility on various aspects of internet communication such as routing protocol changes, implications of realtime traffic and fast handovers, optimizations. These should all support the primary goal of reachability for mobile network nodes. Security is an important consideration too, and efforts should be made to use existing solutions if they are appropriate. Although a well-designed solution may include security inherent in other protocols, mobile networks also introduce new challenges.

For doing so, the NEMO working group has decided to take a stepwise approach by standardizing a basic solution to preserve session continuity (NEMO Basic Support), and at the same time study the possible approaches and issues with providing more optimal routing with potentially nested mobile networks (NEMO Extended Support).

However, the working group is not chartered to actually standardize a solution to such route optimization at this point in time.

For NEMO Basic Support, the working group will assume that none of the nodes behind the MR will be aware of the network's mobility, thus the network's movement needs to be completely transparent to the nodes inside the mobile network. This assumption will be made to

accommodate nodes inside the network that are not generally aware of mobility.

The efforts of the Mobile IP working group have resulted in the Mobile IPv4 and Mobile IPv6 protocols, which have already solved the issue of host mobility support. Since challenges to enabling mobile networks are vastly reduced by this work, basic network mobility support will adopt the methods for host mobility support used in Mobile IP, and extend them in the simplest way possible to achieve its goals. The basic support solution is for each MR to have a Home Agent, and use bidirectional tunneling between the MR and HA to preserve session continuity while the MR moves. The MR will acquire a Care-of-address from its attachment point much like what is done for mobile nodes (MN) using Mobile IP. This approach allows nested mobile networks, since each MR will appear to its attachment point as a single node.

3. NEMO Support Design Goals

This section details the fundamental design goals the solutions will tend to achieve. Those design goals will serve to edict and understand the requirements defined for forthcoming solutions. Actual requirements for NEMO Basic Support are in the next section, whereas NEMO Extended Support has not yet been considered.

3.1 Migration Transparency

A permanent connectivity to the Internet has to be provided to all MNNs while continuous sessions are expected to be maintained as the mobile router changes its point of attachment. For doing so, MNNs are expected to be reachable via their permanent IP addresses.

3.2 Performance Transparency and Seamless Mobility

NEMO support is expected to be provided with limited signaling overhead and to minimize the impact of handover over applications, in terms of packet loss or delay. However, although variable delays of transmission and losses between MNNs and their respective CNs could be perceived as the network is displaced, it would not be considered a lack of performance transparency.

3.3 Network Mobility Support Transparency

MNNs behind the MR(s) don't change their own physical point of attachment as a result of the mobile network's displacement in the Internet topology. Consequently, NEMO support is expected to be performed by the sole MR(s) and specific support functions on any other node than the MR(s) would better be avoided.

3.4 Operational Transparency

NEMO support is to be implemented at the IP layer level. It is expected to be transparent to upper layers so that any upper layer protocol can run unchanged on top of an IP layer extended with NEMO support.

3.5 Arbitrary Configurations

The formation of a mobile network can exist in various levels of

complexity. In the simplest case, a mobile network contains just a mobile router and a host. In the most complicated case, a mobile network is multihomed and is itself a multi-level aggregation of mobile networks with collectively thousands of mobile routers and hosts. While the list of potential configurations of mobile networks cannot be limited, at least the following configurations are desirable:

- mobile networks of any size, ranging from a sole subnet with a few IP devices to a collection of subnets with a large number of IP devices,

- nodes that change their point of attachment within the mobile network,

- foreign mobile nodes that attach to the mobile network,

- multihomed mobile network either when a single MR has multiple attachments to the internet, or when the mobile network is attached to the Internet by means of multiple MRs (see definition in [4] and the analys in [5]),

- nested mobile networks (mobile networks attaching to other mobile networks (see definition in [4]). Although the complexity requirements of those nested networks is not clear, it is desirable to support arbitrary levels of recursive networks, and only in the case where this is impractical and protocol concerns preclude this support should the solution impose restrictions on nesting (e.g. path MTU),

- distinct mobility frequencies (see mobility factor in [3])

- distinct access medium.

In order to keep complexity minimal, transit networks are excluded from this list. A transit network is one in which data would be forwarded between two endpoints outside of the network, so that the network itself simply serves as a transitional conduit for packet

forwarding. A stub network (leaf network), on the other hand, does not serve as a data forwarding path. Data on a stub network is either sent by or addressed to a node located within that network.

3.6 Local Mobility and Global Mobility

Mobile networks and mobile nodes owned by administratively different entities are expected to be displaced within a domain boundary or between domain boundaries. Multihoming, vertical and horizontal handoffs, and access control mechanisms are desirable to achieve this goal. Such mobility type is not expected to be limited for any consideration other than administrative and security policies.

3.7 Scalability

NEMO support signaling and processing is expected to scale to a potentially large number of mobile networks irrespective of their configuration, mobility frequency, size and number of CNs.

3.8 Backward Compatibility

NEMO support will have to co-exist with existing IPv6 standards without interfering with them. Standards defined in other IETF working groups have to be reused as much as possible and extended only if deemed necessary. For instance, the following mechanisms defined by other working groups are expected to function without modidications:

- Address allocation and configuration mechanisms

- Host mobility support: mobile nodes and correspondent nodes, either located within or outside the mobile network are expected to keep operating protocols defined by the Mobile IP working group. This include mechanisms for host mobility support (Mobile IPv6) and seamless mobility (FMIPv6).

- Multicast support entertained by MNNs are expected to be maintained while the mobile router changes its point of attachment.

- Access control protocols and mechanisms used by visiting mobile hosts and routers to be authenticated and authorized to gain access to the Internet via the mobile network infrastructure (MRs).

- Security protocols and mechanisms

- Mechanisms performed by routers deployed both in the visited

networks and in mobile networks (routing protocols, Neighbor Discovery, ICMP, Router Renumbering, ...).

3.9 Secure Signaling

NEMO support will have to comply with usual IETF security policies and recommendations and is expected to have its specific security issues fully addressed. In practice, all NEMO support control messages transmitted in the network will have to ensure an acceptable level of security to prevent intruders to usurp identities and forge data. Specifically, the following issues have to be considered:

- Authentication of the sender to prevent identity usurpation.

- Authorization, to make sure the sender is granted permission to perform the operation as indicated in the control message.

- Confidentiality of the data contained in the control message.

3.10 Location Privacy

Means to hide the actual location of MNNS to third parties other than the HA are desired. In which extend this has to be enforced is not clear since it is always possible to determine the topological location by analysing IPv6 headers. It would thus require some kind of encryption of the IPv6 header to prevent third parties to monitor IPv6 addresses between the MR and the HA. On the other hand, it is at the very least desirable to provide means for MNNs to hide their real topological location to their CNs.

3.11 IPv4 and NAT Traversal

IPv4 clouds and NAT are likely to co-exist with IPv6 for a long time, so it is desirable to ensure mechanisms developped for NEMO will be able to traverse such clouds.

4. NEMO Basic Support One-Liner Requirements

The NEMO WG is to specify a unified and unique "Network Mobility Basic Support" solution, hereafter referred to as "the solution". This solution is to allow all nodes in the mobile network to be reachable via permanent IP addresses, as well as maintain ongoing sessions as the MR changes its point of attachment to the Internet topology. This is to be done by maintaining a bidirectional tunnel between a MR and its Home Agent.

For doing so, the NEMO Working Group has decided to investigate reusing the existing Mobile IPv6 [1] mechanisms for the tunnel management, or extend it if deemed necessary.

The list of requirements below have been placed on the NEMO Basic Support solution. They have been mostly met by the resulting specification which can now be found in [2].

R01: The solution MUST be implemented at the IP layer level.

R02: The solution MUST set up a bi-directional tunnel between a Mobile Router and its Home Agent (MRHA tunnel)

R03: All traffic exchanged between a MNN and a CN in the global Internet MUST transit through the bidirectional MRHA tunnel.

R04: MNNs MUST be reachable at a permanent IP address and name.

R05: The solution MUST maintain continuous sessions (both unicast and multicast) between MNNs and arbitrary CNs after IP handover of (one of) the MR.

R06: The solution MUST not require modifications to any node other than MRs and HAs.

R07: The solution MUST support fixed nodes, mobile hosts and mobile routers in the mobile network.

R08: The solution MUST allow MIPv6-enabled MNNs to use a mobile network link as either a home link or a foreign link.

R09: The solution MUST ensure backward compatibility with other standards defined by the IETF. This include particularly:

R09:1: The solution MUST not prevent the proper operation of Mobile IPv6 (i.e. the solution MUST allow MIPv6-enabled MNNs to operate either the CN, HA, or MN operations defined in [1])

R10: The solution MUST treat all the potential configurations the same way (whatever the number of subnets, MNNs, nested levels of MRs, egress interfaces, ...)

R11: The solution MUST support at least 2 levels of nested mobile networks, while, in principle, arbitrary levels of recursive mobile networks SHOULD be supported.

R12: The solution MUST function for multihomed MR and multihomed mobile networks as defined in [4].

R13: NEMO Support signaling over the bidirectional MUST be minimized

R14: Signaling messages between the HA and the MR MUST be secured:

R14.1: The receiver MUST be able to authenticate the sender

R14.2: The function performed by the sender MUST be authorized for the content carried

R14.3: Anti-replay MUST be provided

R14.4: The signaling messages MAY be encrypted

R15: The solution MUST ensure transparent continuation of routing and management operations over the bi-directional tunnel (this includes e.g. unicast and multicast routing protocols, router renumbering, DHCPv6, etc)

R16: The solution MUST not impact on the routing fabric neither on the Internet addressing architecture. [ACCORDING TO IETF56 minutes, SHOULD BE REMOVED]

R18: The solution MAY preserve sessions established through

another egress interface when one fails

5. Changes Between Versions

5.1 Changes between version -02 and -03

- Mostly cosmetic changes

- Merged section Terminology into Introduction

- Cross-references with other NEMO WG docs

- Changed the introducion of section Section 4 and added reference to NEMO Basic Support's resulting specification.

5.2 Changes Between Version -01 and -02

- removed sub-items in R12 (sub-cases are contained into the definition of multihoming)

- minor typos

- R15: Added "multicast"

- R14.4: SHOULD softened to MAY according to discussion at IETF56th meeting.

- R17 moved to R09 and contains former R09 as a sub-case.

- R18: relaxed from "SHOULD" to may based on Vijay Devarapalli comment (030718)

5.3 Changes Between Version -00 and -01

- title of documents: included the word "goals"

- entire document: some rewording

- section 4: changed title of section to "NEMO Design Goals".

- section 4: removed "MUST" and "MAY"

- section 4: more text about location privacy

- section 4: changed "Administration" paragraph to "Local and Global Mobility". Text enhanced.

- section 5: R02: replace "between MR and MR's HA" with "a MR and its HA" R11: specified at least 2 levels R12: replaced "support" with "function" and add "multihomed MR" R13.x renumbered to R12.x since part of R12 (editing mistake) R13 and R18: new requirements proposed by editor and minor changes in the formulation of other Requirements

6. Acknowledgments

The material presented in this document takes most of its text from discussions and previous documents submitted to the NEMO working group. This includes initial contributions from Motorola, INRIA, Ericsson and Nokia. We are particularly grateful to Hesham Soliman (Ericsson) and the IETF ADs (Erik Nordmark and Thomas Narten) who highly helped to set up the NEMO working group. We are also grateful to all the following people whose comments highly contributed to the present document: TJ Kniveton (Nokia), Alexandru Petrescu (Motorola), Christophe Janneteau (Motorola), Pascal Thubert (CISCO), Hong-Yon Lach (Motorola), Mattias Petterson (Ericsson) and all the others people who have expressed their opinions on the NEMO (formely MONET) mailing list. Thierry Ernst wish to personally grant support to its previous employers, INRIA, and Motorola for their support and

direction in bringing this topic up to the IETF, particularly Claude Castelluccia (INRIA) and Hong-Yon Lach (Motorola).

7 References

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Author's Address

Thierry Ernst
WIDE at Keio University
Jun Murai Lab., Keio University.
K-square Town Campus, 1488-8 Ogura, Saiwa-Ku
Kawasaki, Kanagawa 212-0054
Japan

Phone: +81-44-580-1600
Fax: +81-44-580-1437
EMail: ernst@sfc.wide.ad.jp
URI: http://www.sfc.wide.ad.jp/~ernst/

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Funding for the RFC Editor function is currently provided by the Internet Society.