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IPv4 traversal for MIPv6 based Mobile Routers
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Abstract

Since IPv6 connectivity is not yet broadly available, there is a need in NEMO for a simple technology that allows a MIPv6 based Mobile Router to roam over IPv4 networks.

The Doors Protocol proposed in this memo allows an arbitrary Mobile Node to roam even within private IPv4 address spaces, across both Network and Port Address Translations, in order to cope with existing of deployments of technologies such as GPRS.

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[1.](#) Introduction

This document assumes that the reader is familiar with Mobile IPv6 defined in [\[1\]](#), with the concept of Mobile Router (MR) and with the Nemo terminology defined in [\[2\]](#), as well as IPv4 Network Address Translation (NAT) and Port Address Translation (PAT).

During the transition phase from IPv4 to IPv6, hot spots that actually provide IPv6 connectivity will be scarce and Mobile Routers should support an alternate roaming technology over IPv4.

There is an existing panel of solutions from the NGTRANS WG (ISATAP, 6to4, TEREDO), but these solutions fail to traverse simply every type of NAT and PAT, such as present today in GPRS deployments.

There is a real value in combining MIPv6 and IPv4 traversal technologies. MIP brings a MN-HA tunnel and a binding cache into the picture, as well as a keep alive procedure. The MIP cache can be used to store the PAT/NAT states, while the Binding flow can be tuned to keep the PAT/NAT active. As a result, it is possible for a IPv6 Mobile Router to traverse PAT/NAT with no protocol overhead or additional states in the network.

The Doors Protocol developed in this draft is aimed at the Nemo problem space. In particular, only the MN-HA tunnel is considered (as opposed to any MN-CN tunnel). Also, some restrictions apply that may be circumvented by additional work.

[2.](#) Terminology and concepts

[2.1](#) Doors Handle

Existing technologies such as 6to4 use synthesized IPv6 addresses to build automatic tunnels. In such technologies, the result is still a valid Global IPv6 address, that can be used as Source or Destination

address in IPv6 packets, and points on one of the machine's interfaces.

Here, we synthetize a 128-bits tag, named Doors Handle. The Doors Handle is not a valid Global IPv6 Address, and can not generally be used as a Source or Destination IPv6 address.

The Doors Handle should not be used for upper layer checksums, either: the tag only is meant to be used as an IPv6 address in the header of a packet that is encapsulated inside a IPv4 (UDP) tunnel. In fact, the Doors Handle points on that IPv4 (UDP) tunnel, as opposed to an interface on a machine, and is meant to be used only as a CareOf by MIPv6 Nodes roaming over a IPv4 network.

The Doors Handle has the following format:

```

      0               1               2               3
      0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|               Direction := (InDoors | OutDoors)               |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|   MN   UDP Port               | well-known Doors Port         |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|               MN IPv4 address               |                   |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|               Door IPv4 address               |                   |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

Doors Handle

Direction

The 32-bits protocol ID indicates that the Doors protocol is being used to synthetize this address. At this time, There are 2 IDs defined:

0x12345678: InDoors

0x12343210: OutDoors

MN UDP Port

16-bits UDP Source port, chosen dynamically by the Mobile Node.

Doors Port

16-bits UDP Destination port. A well known value DOORSPORT to be assigned by IANA. For interoperability testing, DOORSPORT of 434 (MIPv4 Port) is used in the meantime.

MN IPv4 Address

32-bits private IPv4 address that the MN acquires dynamically while roaming, using DHCP or IPCP, or that is statically configured.

Door IPv4 Address

32-bits public IPv4 address of the door, that the MN learns dynamically while roaming, using DHCP or IPCP extension (TBD), or that is statically configured.

[2.2](#) Other definitions

DoG

The Doors Gateway (DoG) is the function that terminates the Doors Tunnel on both Home and Mobile ends. The DoG performs IPv4/UDP automatic tunneling and a IPv6 level Network Address Translation.

DooR

A Doors Router (DooR) is a router that implements the Doors Gateway. The Home Door is connected to the Home Network via IPv6. Mobile Routers implementing the Doors Protocol are Mobile DooRs.

Doors Tunnel

The Doors Tunnel is an IPv4/UDP automatic tunnel that encapsulates a Mobile IPv6 tunnel. The Tunnel has two Directions, InDoors and OutDoors.

InDoors

A packet going InDoors flows between the Mobile Node and the DoG. An InDoors packet is characterized by a Source IPv6 address that is an InDoors Handle. An InDoors Handle is generated by the Mobile Node, with the Direction field set to InDoors.

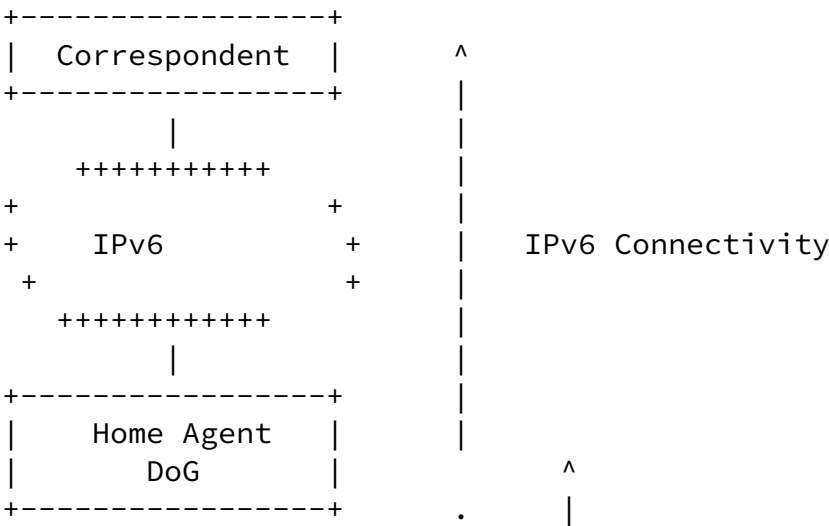
OutDoors

A packet going OutDoors flows between DoG and the Mobile Node. An OutDoors packet is characterized by a Destination IPv6 address that is an OutDoors Handle. An OutDoors Handle is generated by the DoG, based on an InDoors Handle, after the IPv4 Address Translation, with the Direction field set to OutDoors.

3. Basic MIPv6 Doors support

The Basic MIPv6 Doors support collocates a DoG function with the Home Agent. A roaming Mobile Node generates an InDoors Handle and uses it as CareOf to Bind over a Doors Tunnel to its Home Agent. All packets are sent over the MN-HA tunnel, with no Route Optimization.

When sending a packet with a Source IPv6 address that is an InDoors Handle, the Mobile Node automatically tunnels the packet over the associated Doors tunnel. In turn, when sending a packet with a Destination IPv6 address that is an OutDoors Handle, a HA automatically tunnels the packet over the associated Doors tunnel.



Also, since the Doors Handle is not a valid IPv6 address, the packet can not be forwarded after UDP decapsulation, so in basic MIPv6 mode, the UDP tunnel MUST be terminated by the Home Agent.

Most of these limitations can be circumvented, but this is not covered in this version of this draft, in order to keep it simple. Yet, binding flows and MN-HA tunneling purposes, the Nemo requirements can be fulfilled by the procedures described hereafter.

[3.2](#) Operation for a MIPv6 Mobile Node roaming over IPv4

A MN roaming generates its InDoors Handle as follows:

+-----+-----+-----+-----+-----+				
InDoors	xxxx	DOORS	MN private @	Door public @
+-----+-----+-----+-----+-----+				

InDoors Handle

Direction: InDoors

MN UDP port: A value chosen dynamically by the Mobile Node. It may be a signature used for verification purposes.

Doors Port: DOORSPORT

MN IPv4 address: the private IPv4 CoA acquired by the mobile router on his roaming interface by any mechanism (configuration, DHCP, IPCP, ...)

Door IPv4 address: An IPv4 address of the Home Agent.

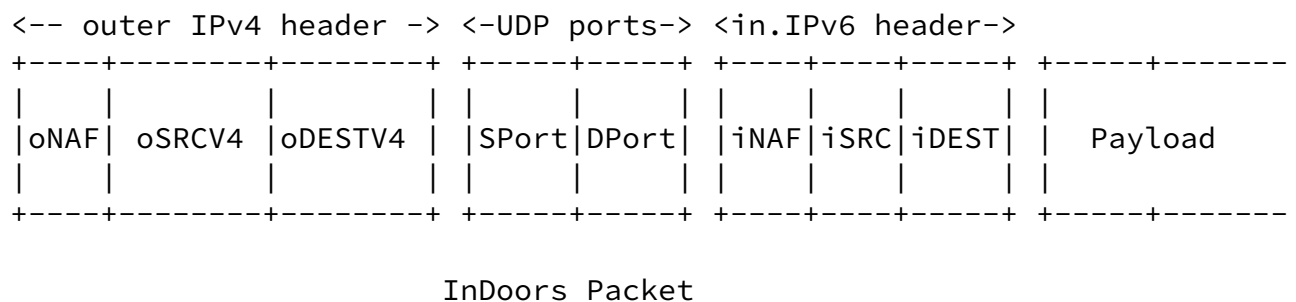
The Mobile Node may recompute a new port periodically, build a new CareOf and rebind.

The Mobile Node MUST be tuned to send Binding Updates often enough to make sure that the NAT/PAT states are kept alive. As a result, there is no additional control traffic for that purpose.

3.2.1 Sending packets over the Doors tunnel

According to non-optimized MIPv6 and basic Nemo principles, the Mobile Node, and in particular if it is a Nemo Mobile Router, uses the MN-HA tunnel for all communications with the Infrastructure, sourcing packets with the CareOf and using the Home Address Option to pass the address that is actually used as Source for upper layer purposes.

When sending or forwarding a IPv6 packet with a Source address that is a Door Number with a InDoors Handle, a Mobile Node MUST encapsulate the packet into a IPv4/UDP tunnel using the following settings:



NAF represents the Non-Address Fields of a IP header

Sport is the UDP Source port, set to the MN UDP port from the Handle

DPort is the UDP Destination Port, set to the Doors Port from the Handle

SRCV4 is the Source IPv4 address, set to the MN IPv4 address from the Handle

DESTV4 is the Destination IPv4 address, set to the Door IPv4 address from the Handle.

SRC is the IPv6 Source Address, set to CoA == InDoors Handle

DEST is the Home Agent Address

The Payload may be Home Address Dest Option and a Mobility Header or a IPv6 packet from a Node in the Mobile Network

This causes packets in the MN-HA tunnel to be automatically reencapsulated into an IPv4/UDP tunnel to the HA IPv4 address, as long as the CareOf Address is a Doors Handle.

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[3.2.2](#) Receiving packets over the Doors tunnel

The process of terminating the Doors tunnel on the MN side is:

- Decapsulating the IPv6 packet from the IPv4/UDP encapsulation

- Recomposing the original IPv6 address as known on the MR side.

When receiving a packet over UDP with Source Port equal to DOORSPORT, a Mobile Node checks whether there's an inner IPv6 packet with a Destination IPv6 address that is actually a Doors Handle.

If so, and if the Direction of the Handle is OutDoors, the MN restores its InDoors Handle by:

- Overwriting the Direction to InDoors

- Overwriting the MN IPv4 address field with the IPv4 Destination address from the received packet

- Overwriting the MN UDP port field with the UDP Destination port from the received packet

If the generated Doors Handle does not match its CareOf, the node drops the packet.

Then, the node decapsulates the UDP tunnel and receives the resulting IPv6 packet. The result is either yet another level of decapsulation, or, in the case of a RH type 2, a forwarding to the next hop in the RH, that should be the node's home address.

This causes the MN-HA tunnel to be automatically decapsulated from an IPv4/UDP tunnel as long as the Doors Handle is the CareOf.

[3.3](#) Operation for the Home Agent of a MIPv6 MN roaming over IPv4

For basic MIPv6 Doors support, Home Agent runs the DoG, and the OutDoors Handle is stored as CareOf in the Binding Cache.

[3.3.1](#) Receiving packets over the Doors tunnel

The process of terminating the Doors Tunnel on the HA side is:

Decapsulating the IPv6 packet from the IPv4/UDP encapsulation

Translating the original source IPv6 address into an OutDoors Handle.

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When receiving a packet over UDP with Source Port equal to DOORSPORT, the DoG function in a HA checks whether there's an inner IPv6 packet with a Source IPv6 address that is actually a Doors Handle.

If so, and if the Direction is InDoors, DoG translates the Handle by:

Overwriting the Direction to OutDoors

Overwriting the MN IPv4 address field with the IPv4 Source Address from the received packet

Overwriting the MN UDP port field with the UDP Source port from the received packet

As a result, the layout of the OutDoors Handle is as follows:

OutDoors	yyyy	DOORS	MN public @	Door public @
----------	------	-------	-------------	---------------

OutDoors Handle

Direction: OutDoors

MN UDP port: May have been PATed

Doors Port: DOORSPORT

MN IPv4 address: the public IPv4 address of the MN if NATed

Door IPv4 address: An IPv4 address of the Home Agent.

At that time of translating the Handle, the DoG knows both the InDoors and OutDoors tags. It may save the InDoors Handle for AH

computation and upper layer checksums, should there be a need for it.

Then, the DoG decapsulates the UDP tunnel and receives the resulting IPv6 packet. As the HA is collocated with the DoG, the packet is received and the OutDoors Handle is used as CareOf and stored in the binding cache.

So the transition between IPv4 and IPv6 roaming is smooth, handled by the DoG function, transparently to the HA support.

[3.3.2](#) Sending packets over the Doors tunnel

When the HA forwards packets to a Mobile Node that is not at home, it encapsulates them over the MN-HA tunnel. The Destination IPv6 address is the translated CareOf Address of the MN, that is the OutDoors Handle of that MN if it is roaming over IPv4 using the Doors Protocol.

When sending or forwarding a IPv6 packet with a Destination address that is an OutDoors Handle, the DoG function in the Home Agent MUST encapsulate the packet into a IPv4/UDP tunnel using the following settings:

```
<-- outer IPv4 header -> <-UDP ports-> <in.IPv6 header->
+-----+-----+-----+ +-----+-----+ +-----+-----+ +-----+-----+
|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|oNAF| oSRCV4 |oDESTV4 | |SPort|DPort| |iNAF|iSRC|iDEST| | Payload
|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
+-----+-----+-----+ +-----+-----+ +-----+-----+ +-----+-----+
```

InDoors Packet

NAF represents the Non-Address Fields of a IP header

Sport is the UDP Source port, set to the Doors Port from the Handle

DPort is the UDP Destination Port, set to the MN UDP port from the Handle

SRCV4 is the Source IPv4 address, set to the Door IPv4 address from the Handle.

DESTV4 is the Destination IPv4 address, set to the MN IPv4 address from the Handle

SRC is the Home Agent Address

DEST is the IPv6 Source Address, set to the mapped CoA == OutDoors Handle

The Payload may start with a Routing Header of type 2, or be a IPv6 packet from a Node in the Mobile Network

When applied to Nemo, between a Mobile Router and its Home Agent, the Doors protocol maintains a single state in the PAT/NAT for all the communications of all the Mobile Network Nodes.

[4.](#) Distributed configurations

With the basic MIPv6 Doors support, the Home Door is necessarily collocated with the Home Agent. This is fine for a small, collapsed configuration (A single HA/Door), but more of a problem for a larger, distributed configuration. Further improvements, described hereafter, allow for a distribution of that functionality.

[4.1](#) Hierarchical MIP

A Mobility Anchor Point (MAP), as defined in [\[4\]](#) can be used to terminate the Doors tunnel on behalf of the Home Agent. This permits a distributed configuration with no dependencies of between the number of MAPs and the number of HAs.

A new IPv4 region is defined, and several MAP/Doors can be deployed to handle that region. They keep a state for the Mobile Nodes that use their service for Regional mobility, but advertise their own Global IPv6 address to the Home Agent, which uses it as the MN CareOf.

As a result, the HA is transparent when a IPv4 traversal occurs.

4.2 Reverse Routing Header

The RRH, as defined in [3] provides an alternate technique to distribute the Doors Gateways for roaming Mobile Routers. In this case, a number of Mobile Routers, called Stray DoGs are deployed on the Home Network side of the IPv4 Network, and configured to be "not at home" - even though they do not move-, and to be Home Doors.

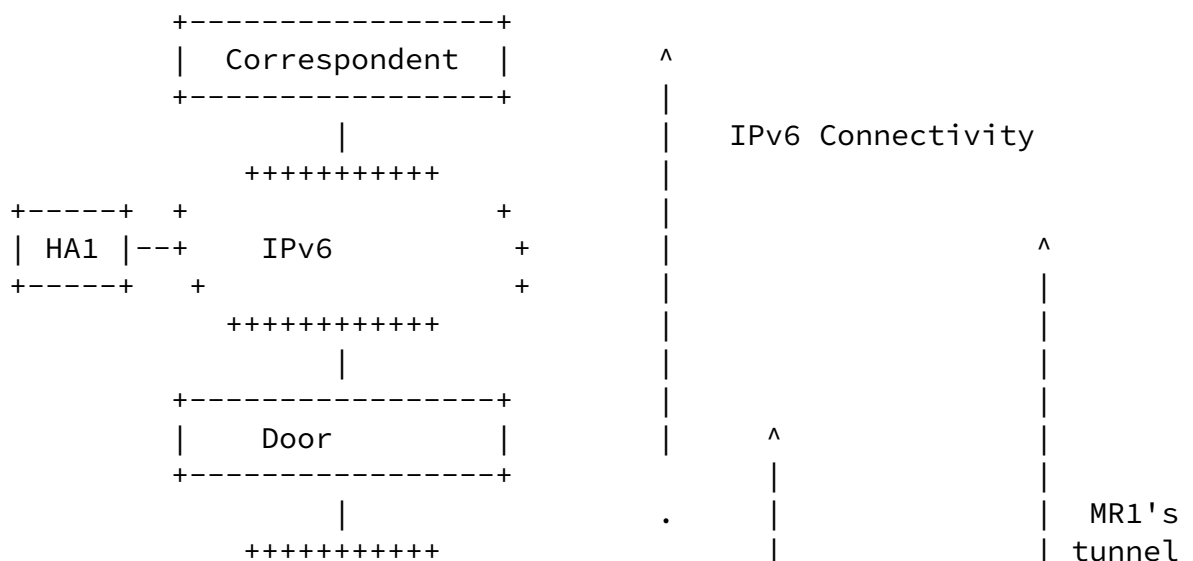
Since they are not at home, the Stray DoGs perform the procedure defined in [3] for a roaming Mobile Router, when forwarding a packet decapsulated by the DoG:

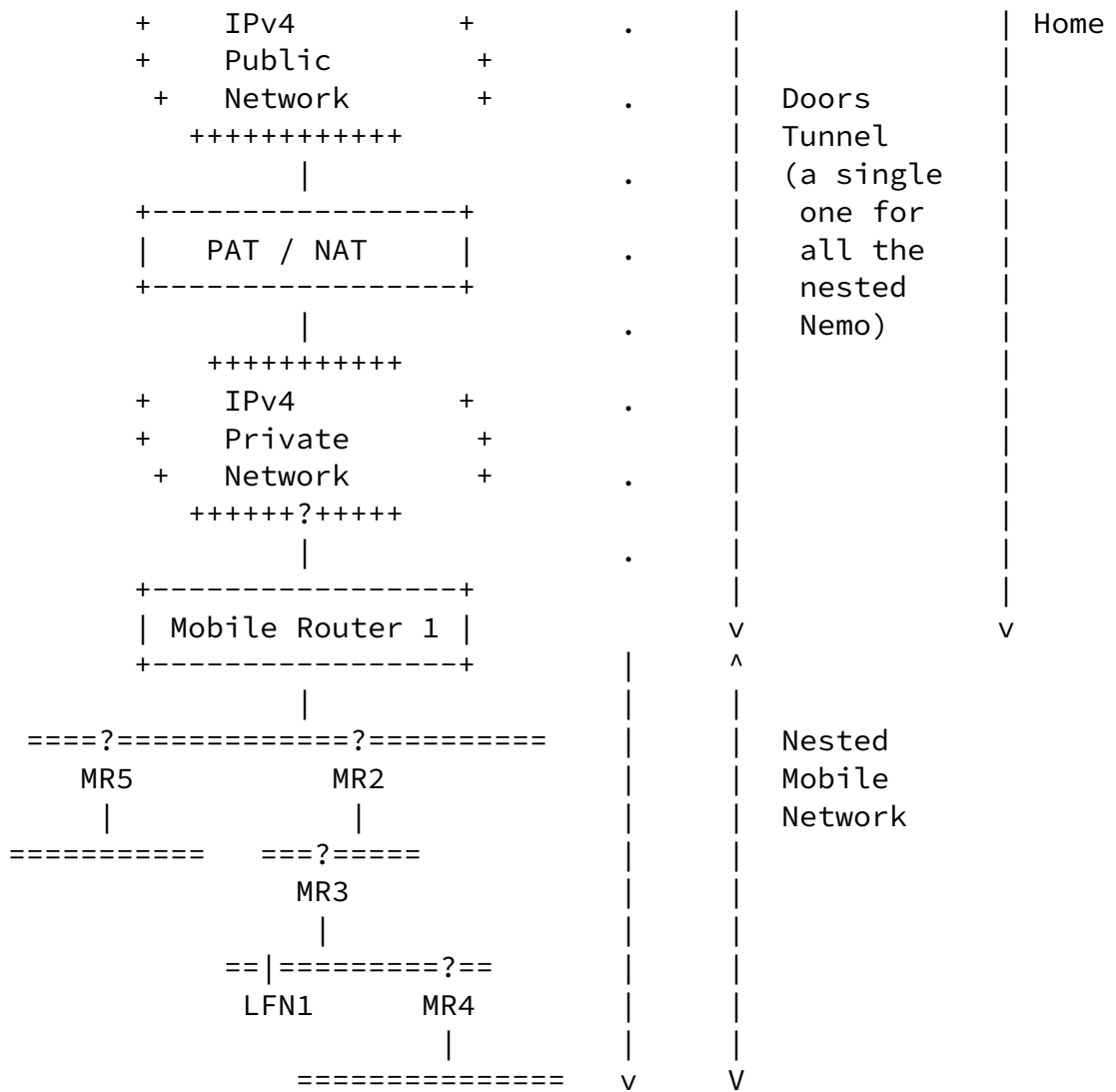
They swap the Source address with their own (Global IPv6) CareOf Address, adding the original Source (the OutDoors Handle) to the RRH.

As a result, the Home Agent is again transparent to the fact that IPv4 traversal occurred.

The whole IPv4 network is now considered as the Mobile Network of the Doors gateways. As a result, the Mobile Router roaming over IPv4 is considered at a depth of one, attached to its selected Doors Gateway.

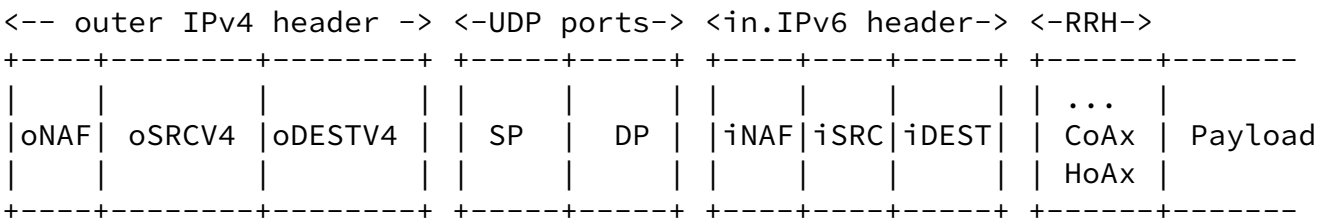
Other MRs may be attached to that roaming MR in a nested Nemo Fashion. Each one maintains a tunnel to its home Agent, while all of these tunnels share the same IPv4/UDP end points.





Doors with RRH

With RRH, the InDoors packets are formatted as follows:



InDoors Packet with RRH support

NAF represents the Non-Address Fields of a IP header

Sport is the UDP Source port, set to the MN UDP port from the Handle

DPort is the UDP Destination Port, set to the Doors Port from the Handle

SRCV4 is the Source IPv4 address, set to the MN IPv4 address from the Handle

DESTV4 is the Destination IPv4 address, set to the Door IPv4 address from the Handle.

SRC is the IPv6 Source Address, set to CoA == InDoors Handle

DEST is the Home Agent Address

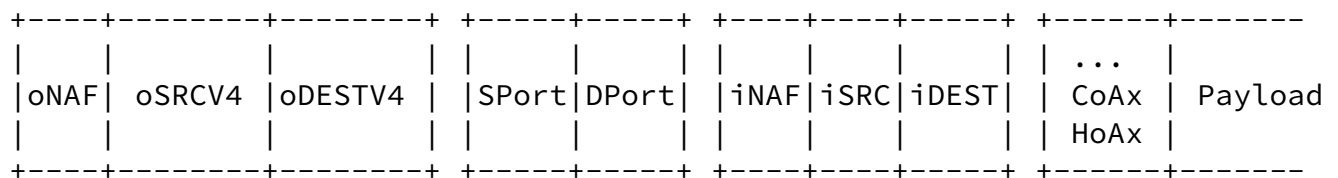
RRH contains the Source Routed path to the First MR down the nested Nemo, that is the real tunnel endpoint

The Payload may start with a Home Address Destination Option and a Mobility Header or a IPv6 packet from a Node in the Mobile Network

The packets on the return path are sent by the Home Agent to the Stray DoG that originated the inbound packets.

The encapsulating headers contains a Routing Header of type 2 derived from the RRH. Conforming the RH type 2 processing, the Stray DoG needs to forward the packet to the first entry in the Routing Header, which happens to be a OutDoors Handle.

When sending or forwarding a IPv6 packet with a Destination address that is an OutDoors Handle, the Stray DoG MUST encapsulate the packet into a IPv4/UDP tunnel using the following settings:



OutDoors Packet with RRH support

NAF represents the Non-Address Fields of a IP header

Sport is the UDP Source port, set to the Doors Port from the Handle

DPort is the UDP Destination Port, set to the MN UDP port from the Handle

SRCV4 is the Source IPv4 address, set to the Door IPv4 address from the Handle.

DESTV4 is the Destination IPv4 address, set to the MN IPv4 address from the Handle

SRC is the Home Agent Address

DEST is the IPv6 Source Address, set to the mapped CoA == OutDoors Handle

The Routing Header type 2 contains the Source Routed path to the First MR down the nested Nemo, that is the real tunnel endpoint

The Payload is a IPv6 packet to a Node in a Mobile Network behind the Mobile Router HoAx

This solution presents a number of advantages:

This solution does not keep states in the gateways. The NATed addresses are stored and maintained in the Home Agent binding cache, as long as they are needed, by the Mobile IPv6 protocol.

The MR may swap its Doors Gateway whenever it needs, since this will seen as yet an other roaming. In particular, the -optionally local, private- address of a local Doors Gateway may be available in a DHCP or an IPCP extension.

There is only one entry in the NAT/PAT gateway for a full Nested Nemo configuration. This limits the size of the tables that the NAT gateway has to maintain.

[5.](#) IANA considerations

A port number value is required for DOORSPORT. Note that this requirement could be alleviated by a common configuration on both sides, but this makes the deployment a bit more complex.

The values for InDoors and OutDoors also have to be standardized. 0x12345678 and 0x12343210 are given for interoperability testing in the meantime.

[6.](#) Acknowledgements

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