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Mobile Network Prefix Delegation
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Abstract

This paper extends the Nemo Basic Support [9] for a Mobile Router to synchronize its Mobile Network Prefixes with its Home Agents and obtain new ones dynamically.

The proposed prefix delegation mechanism is agnostic to the way the back end is implemented; it enables bootstrapping, resynchronization at binding creation or after a loss of states (eg MR reboot), MNP

Renumbering, and configuration checking for loop avoidance.

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1. Introduction

The reader of that document is expected to be familiar with both the Mobile IPv6 [8] and NEMO Basic Support [9] documents. As such, it is well-understood that neither protocol provides the means for provisioning the Mobile Nodes and Routers with essential parameters such as Home Address and Home Network.

The process by which a router obtains a prefix dynamically is called prefix delegation. In the NEMO context, the prefix is managed by an authority than owns the Home Network and subnets it into MNPs that it assigns to the MRs. An MNP can be preassigned to the associated MR (e.g. manually or automatically with a provisionning system), or assigned dynamically by a server such as a DHCP Prefix Delegation server.

As prescribed by [9], the HA checks whether a MR is authorized for the MNPs it claims as part of the NEMO Binding Update with the explicit prefix option. Also, MNPs have to belong to an aggregation that is permanently advertised be the HA to the routing infrastruture. Consequently, there is a strong relationship between the HA that the MR registers to and the prefixes it claims with the registration, and it makes sense for the HA to participate actively to the delegation process as well.

[9] standardizes an interface between a Mobile Router and its Home Agent, as well as an interface between Home Agents. The protocol is agnostic as to how the back end is implemented in terms of AAA, provisioning, or routing between the HAs and their IGP, and enables various forms of deployment, as described in [14].

In a same fashion, the document extends [9] for a Mobile Router to obtain its Mobile Network Prefix dynamically from its Home Agent, with no assumption about the specific back-end implementation for prefix management and service authorization.

2. motivation for a NEMO prefix delegation

A number of reasons plead for adding this capability to NEMO NEMO Basic Support [9].

Mainly, there is an unanswered question as to how a MR could be dynamically assigned its prefix. In a situation where a site has many MRs, it may be impractical to assign the prefixes statically in the non-volatile memory of the MR. Consequently, we would like a mechanism for the HA to assign the prefix, similar to how a MN can bootstrap its Home Address.

2.1 Configuration management

The Implicit Mode of the NEMO Basic Support 'externalizes' the configuration of the MNPs in a MR and its HA. In the example of a static configuration, both side are initially provisioned with the association between the MRs and their MNPs, and maintain matching states between them.

The failure to configure and maintain these matching states overtime ends up in routing loops and unreachable prefixes. Tools for synchronizing MNPs in runtime would be a valuable addition to [9].

2.2 Provisioning

In practice, provisioning both sides manually is error-prone and should be avoided. It can not be taken for granted, either, that in all cases, a provisioning system can be deployed with the capability to configure both the Mobile Router and the back-end in a transactional manner. Consequently, it appears necessary to provide a way to configure one side only, and have the other side learn from it in a trusted fashion and with no additional manual intervention.

The Explicit Prefix mode enables a flow where the configuration of that association is not centralized at the HA but distributed to all the MRs. In fact, the HA is required to validate that the MR has been authorized for the MNPs it claims and then again, some level of information duplication might occur.

In the general case, it may be easier to manage the prefix attribution in a centralized manner and have the MRs learn their prefixes dynamically.

2.3 Renumbering

The concept of lifetime is one core idea with IPv6. Nothing is eternal. Overtime, it might be desirable to modify the configuration of the MNPs. This task, called renumbering, is especially difficult for Mobile Routers when they are geographically distributed and not be readily available to the administrators.

It is thus desirable to extend [9] with a renumbering mechanism. In particular, it makes sense to provide that extension within the prefix delegation mechanism, since the operations that take place are vastly similar.

2.4 The NEMO bootstrap problem

Nemo basic support expects a Mobile router to be provisioned with

some information in order to start up - Home Network or Home Agent address, Home Address, Mobile Network Prefixes, security tokens, etc...

In some situations, it may be impractical to actually provision all this information into the router at deployment time, and some of it has to be obtained dynamically when a system boots up, possibly through manually keying by the final user.

It is absolutely required to reduce such manual keying of information to the bare minimum, like a user ID and password. And while NEMO can benefit from the MIP6 effort on the bootstrap problem (as described in the MIP6 bootstrap problem statement document [13]) for most parameters, the dynamic provisionning of Mobile Network Prefix(es) is not considered by MIPv6.

2.5 Local Mobility Management

In turn, the bootstrap problem is linked to the Local Mobility Management problem; some LMM solutions such as HMIP deploy regional Home Agents from which bootstrap information has to be obtained when moving into their area of coverage; as opposed to the initial bootstrap problem which occurs at the first startup of a device and may not happen again for an extensive period of time, LMM is tied to movement, and could be quite frequent.

3. Requirements

There is thus a need for a Mobile Router to obtain dynamically one or more MNPs, linked to the HA that the MR binds with.

Since the process may be used as part of a mobility scenario, there is also a need to optimize the delegation flow by limiting the number of protocol exchanges that take place for delegation and registration.

Since the initial configuration may be erroneous or may need to evolve overtime, there is a need to manage the MNPs on a Mobile Router. This includes initial setting up, and synchronizing overtime.

4. Rationale

This section details the rationale behind some of the design decisions that lead to this solution.

4.1 Which capabilities?

4.1.1 Prefix Request capability

The minimum capability that could be envisionned for a NEMO Prefix Delegation mechanism is for a MR to request for a new prefix in a Binding Update and for the HA to provide the prefix as part of the Binding Acknowledgement. Then the Mobile Router installs the newly obtained prefix on the interface that needs it, and moves forward in implicit or explicit mode.

4.1.2 Full prefix list capability for HA

The capability to request a new prefix is sufficient in a basic delegation flow where a MR that is already bound and -hopefully-synchronized with its HA in terms of prefix ownership; it is also required in some bootstrapping and renumbering flows; but it is hardly sufficient in order to synchronize the MR and the HA states regarding MNPs:

Bootstrapping: At bootstrapping time, the MR needs the list of all the prefixes that are attributed in order to populate its interfaces. Asking them one by one and having to make a distinction between already allocated prefixes versus dynamic allocation would make the flow much more complex.

Expired prefixes: That list is also needed for a MR in order to synchronize its current configuration with that of the HA. In particular, it is used for a MR to discover when the HA does not have the associated states in place for one of its MNPs. This may happen for some configuration error or because the prefix has expired, and the only way to know is if the prefix is missing in a full list of all prefixes by the HA.

Newly allocated prefixes: Finally, the list is needed for a MR to learn new prefixes that would be attributed in runtime, and to install those prefixes on its interfaces. Once the new prefixes are installed, it is required that the MR confirms its use of the prefixes so that the HA can set up routing in a loopfree fashion.

So the capability for a HA to list all the prefixes for a MR is needed for the MR to realize that the HA is missing some states and eventually to try to get the missing prefixes in explicit mode. This may happen on demand by the MR (e.g. at bootstrap time or binding creation time), or whenever the HA needs to communicate about a change, such as a shortened or expired MNP lifetime.

4.1.3 Full prefix list capability for MR

So the capability for a HA to list all the prefixes is not sufficient is the HA is not the repository of that knowledge. It might be simpler for the MR to dump its own list of prefixes and have the HA check the list, even for implicit prefixes.

4.2 Rationale for new Binding options

Associated to the capability to request a new prefix, it seems relevant to specify whether the prefix is for implicit or explicit mode, or if its lifetime is limited with that of the binding cache or not. Other fields such as the prefix length are needed as well. In order to convey that information, an optional field is needed in the BU.

It is not desirable to extend the existing NEMO MNP option, which carries a prefix that is not needed, though. As a result, we propose a new option type, the MNP request option.

Associated to the capability for a HA to list all the prefixes for a MR, one critical information is needed, that would not fit in the NEMO MNP option. Again, we propose a new option for the Binding Acknowledgement, the MNP confirm option.

4.3 Rationale for a new bit in the BU

A single bit in the BU is enough for a MR to request a full list of prefixes from the HA, if we do not need a filter of any sort????

It is important that the HA set that bit in its full list of prefixes in order to differentiate between an empty list (there's no prefix for that MR) and no list (HA is not providing a list in that BA).

4.4 Why not Alternate standard based solutions?

Proposing a new, specific solution might seem irrelevant when a standard, generic mechanism already exist, in this case the DHCPv6 Prefix Delegation. In fact, it is possible for the Home Agent to act as a DHCPv6PD Delegating Router. This solution presents the advantage of reusing existing standard flows from RFC3633 [6].

Yet, in a deployment where the MNPs are preassigned to the MR, a AAA server, interfacing with the HA, and eventually coupled with a provisioning system in its back end, can provide the required service for assigning and authorizing the prefixes to the MRs; in such a case, the value of implementing a DHCPv6PD server is highly arguable. It is more generic to let the HA handle the backend interfaces on

behalf of the MR and expose a consistent NEMO interface for all deployments.

In more details, a DHCPv6PD based solution presents a number of inconveniences:

Delegating Router: A collocated Delegating Router function may not be available for all implementation of NEMO Home Agent. In particular, some implementations are server based.

Operational overhead: Depending on the mechanism that is used to attribute the MNPs to the MRs, the Delegating function, even if available, might be a costly overhead. Rather, an embedded, back-end agnostic flow might be a desirable option.

Movement overhead: Some flows, for instance local mobility management, might require a prefix delegation as part of the handling of the movement. Segregating the delegation from the binding adds a round trip delay to the recovery from the movement.

Binding Lifetime: It might be useful to associate implicitly the lifetime of a delegated prefix with that of the binding. This pleads for a design that places the Home Agent function in the flow by construction.

Authentication Mechanism: While NEMO basic Support protects its own flows, there is no mandate to secure the tunneled packets.

Back-end interaction: If a prefix is attributed to a MR for a duration that exceeds that of its binding, this information needs to be shared with all HAs, at least for authorization purposes. This requires a specific backend integration that does not exist in the Prefix Delegation Function, for instance via a AAA server.

5. Terminology and concepts

The key words MUST, MUST NOT, REQUIRED, SHALL, SHALL NOT, SHOULD, SHOULD NOT, RECOMMENDED, MAY, and OPTIONAL in this document are to be interpreted as described in RFC2119 [1].

Most of the mobility related terms used in this document are defined in the Mobility Related Terminology document [7] and in the mobile IPv6 specification [8].

Additionally, some terms were created or extended for NEMO. These specific terms are defined in the Mobile Network Terminology document [12]

This draft introduces the following definitions:

Mobile Network Prefix Request (MNPReq) Option: A new optional field in the MIP6 Mobility Header for use with the binding Update message, as described further in this document. This field is set by a MR to request the delegation of a new prefix as a Mobile Network Prefix.

Mobile Network Prefix Confirm (MNPConf) Option: A new optional field in the MIP6 Mobility Header for use with the binding Acknowledgement message, as described further in this document.

transient prefix: A prefix that is attributed to a Mobile Router in association with a binding cache entry. If the BCE is removed, the prefix is freed.

Persistent prefix: A prefix that is attributed to a Mobile Router for a period of time that does not depend on the existence of a binding cache entry.

6. Overview

6.1 New mobility Headers

This paper introduces a new option to the MIP6 Mobility Header, for use with the binding Update message, the Mobile Network Prefix Request Option. A MR may include one or more MNPReq option(s) in a Binding Update message at any time, in order to obtain additional prefixes.

This paper introduces another new option to the MIP6 Mobility Header, for use with the binding Acknowledgement message, the Mobile Network Prefix Confirm Option. An HA will include one or more MNPConf option(s) in a Binding Acknowledgement message, either in response to a Mobile Network Prefix Request Option, or for its own purposes, for instance in order inform a MR of a change about the lifetime of an MNP.

6.2 New Prefix Status bit

This paper finally introduces a new bit to the MIP6 Binding Update and Binding Acknowledgement, the Prefix Status bit. A MR may include the Prefix Status bit in a binding Update message at any time, either in order to get its initial configuration, or to check whether its current configuration matches that of the Home Agent - which might be particularily useful in implicit mode. When the Prefix Status bit is set in the BU, the Acknowledge bit MUST be set as well.

The HA MAY set the Prefix Status bit in the Binding Acknowledgement even if it was not set by the MR in the Binding Update; the other way around, if the Prefix Status bit was set in the BU, then the HA MUST echo it in the BA. When setting the Prefix Status bit, the HA also lists all the prefixes associated to that Mobile Router using Mobile Network Prefix Confirm options.

6.3 Prefix lease duration

A prefix may be obtained for the duration of the binding; in this case, the prefix is called 'transient'. On the other hand, a prefix can be assigned to a MR for a duration that is independent of a BCE lifecycle, and that is controlled externally by the HA administrator; in that case, the prefix is called 'persistent'.

A flag in the MNPReq option indicates the expectation of the MR in terms of persistence for the requested prefix. If the HA can not fulfill that expectation, it must reject the binding with a negative status.

The lease of a transient prefix expires with the MR Binding Cache Entry; as a result, transient prefixes can be managed internally by a HA, for instance using a local pool that forms an aggregation owned by the HA.

One the other hand, some of the information about a persistent prefix has to be shared between the HAs in a Home Network and the back end systems that enable the authorization. This is required to allow a Mobile Router to rebind, with the same persistent prefixes, to a different Home Agent, after a period of inactivity.

It is possible to assign a persistent prefix dynamically at the time of the delegation; but the persistent mode also enables the preassignment of an MNP to an MR, for instance by provisionning a AAA server with the necessary information for each Mobile Router.

6.4 Renumbering

It is possible to redeploy the persistent prefix space, for instance if Home is being renumbered, or if a dynamically attributed prefix has not been bound for a long period of time. In that case, the HA rejects a new binding as the routing states can not be set up, and the MR has to request one or more new persistent prefix(es).

6.5 backward compatibility

An HA that would not support this extension will ignore the unrecognized option. Else, if the HA supports this draft, and if a binding update with the MNPReq option can be accepted per the NEMO basic support checkings:

6.6 PD flow

When a MR needs an additional prefix to populate an interface, it adds an MNPreq option to its Binding update message.

If the HA can obtain the required prefix for that MR, it operates following the NEMO basic support, either in Implicit Mode, or in explicit mode using the prefixes as if they were received with the BU. This includes setting up the routing states and responding with a positive or a negative status.

If the routing states are established correctly and the HA responds with a positive status, then the HA adds the prefix list to the binding ack message.

From that point on, both the MR and the HA operate as prescribed by the NEMO basic standard, either in implicit or in explicit mode.

7. Message Formats

7.1 Binding Update

A new flag (S) is included in the Binding Update to indicate to the Home Agent that the MR wishes to get the full list of all prefixes that are already assigned to it. The rest of the Binding Update format remains the same as defined in [9].

When the (S) bit is set, the (R) and and (A) bits MUST be set as well.

```
                     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
                                +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                                |          Sequence #           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|A|H|L|K|M|R|S|    Reserved     |           Lifetime            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
.                                                               .
.                        Mobility options                       .
.                                                               .
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1: Binding Update

Prefix Status (S) The Prefix Status (S) bit is set by a MR to request the full list of all prefixes that are already assigned to it

7.2 Binding Acknowledgement

A new flag (S) is included in the Binding Acknowledgement to indicate to the Mobile Router that the Home Agent provides the full list of all prefixes that are already assigned to the MR. The rest of the Binding Acknowledgement format remains the same as defined in [9].

When the (S) bit is set, the (R) bit MUST be set as well.

```
  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
                                 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                                 |   Status      |K|R|S|Reserved |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |         Sequence #            |           Lifetime            |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                                                               |
 .                                                               .
 .                        Mobility options                       .
 .                                                               .
 |                                                               |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 2: Binding Acknowledgement

Prefix Status (S) The Prefix Status (S) bit is set by a HA to indicate that it provides the full list of all prefixes that are already assigned to the MR.

7.3 Mobile Network Prefix option

New flags are included in the Mobile Network Prefix option defined in [9]. This allows the option to cover all the prefixes owned by the MR, including those that are managed using the implicit prefix mode.

```
     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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |      Type     |   Length      |P|I|D|Reserved1| Prefix Length |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                                                               |
    +                                                               +
    |                                                               |
    +                   Mobile Network Prefix                       +
    |                                                               |
    +                                                               +
    |                                                               |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 3: Mobile Network Prefix option

The new flags introduced by this specification are:

Persistent (P) The (P) bit is set if the prefix is expexted to be persistently assigned to the MR.

Implicit (I) The (I) bit is set if the prefix is expexted to be assigned to and routed via the MR even if the prefix is not listed in explicit mode BU.

Delegated (D) The (D) bit is set if the prefix was obtained using a the Delagation Mechanism as described in this specification. It is used to acknowledge that a previously delegated prefix is actually installed and routable via the Mobile Router.

7.4 Mobile Network Prefix request option

This new option is included in the Binding Update to indicate to the Home Agent that the MR wishes to get a new prefix assigned to it for use as a MNP.

When this option is present, the (S) MAY be set as well in the BU in order to get the full list of all prefixes.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |    Length     | Prefix Length |P|I| Reserved1 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     CorID                     |   Reserved2   | Prefix type   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4: Mobile Network Prefix request option

Type TBA

Length 8 bit unsigned integer indicating the length in octets of the option excluding the type and length fields. Set to 6.

Prefix Length 8 bit unsigned integer indicating the prefix length of the IPv6 prefix contained in the option.

Persistent (P) The (P) bit is set if the prefix that is requested to expected to be persistently assigned to the MR.

Implicit (I) The (I) bit is set if the prefix that is requested to expected to be assigned to, and routed via the MR, even if the prefix is not listed in explicit mode BU.

CorId A Correlator that is set by the MR in order to associate a MNP request with the prefix given in the confirm. There can be at most one active prefix associated with each Correlator. This mechanism ensure the unicity of the allocation of a prefix, should aither the BU or the BA be lost in the way.

Prefix Type Indicates the type of prefix that is requested:

0 None Specified

2 Unique Local

3 Global

7.5 Mobile Network Prefix Confirm option

This new option is included in the Binding Update to indicate to the Home Agent that the MR wishes to get a new prefix assigned to it for use as a MNP.

When this option is present, the (S) MAY be set as well in the BU in order to get the full list of all prefixes.

```
  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
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |     Type      |    Length     | Prefix Length |P|I|D|Reserved1|
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |     CorID                     |   Reserved2   | Prefix type   |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                         Valid Lifetime                        |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                                                               |
 +                                                               +
 |                                                               |
 +                    Mobile Network Prefix                      +
 |                                                               |
 +                                                               +
 |                                                               |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5: Mobile Network Prefix Confirm option

Type TBA

Length 8 bit unsigned integer indicating the length in octets of the option excluding the type and length fields. Set to 26.

Prefix Length 8 bit unsigned integer indicating the prefix length of the IPv6 prefix contained in the option.

Persistent (P) The (P) bit is set if the prefix is persistently assigned to the MR.

Implicit (I) The (I) bit is set if the prefix is assigned to and routed via the MR even if the prefix is not listed in explicit mode BU.

Delegated (D) The (D) bit is set if the prefix was obtained using a the Delagation Mechanism as described in this specification.

CorId If the (D) bit is set, the Correlator that was set by the MR in an MNPReq and this option contains the prefix that is being delegated in response to that Request. If the (D) bit is not set, the Correlator value is defined by the HA.

Prefix Type Indicates the type of prefix that is requested:

0 None Specified

2 Unique Local

3 Global

Valid Lifetime 32-bit unsigned integer. The length of time in seconds (relative to the time the packet is sent) that the prefix is valid for being installed on an MR ingress interface. A value of all one bits (0xffffffff) represents infinity. The Valid Lifetime is also used by RFC2461 [3] and RFC2462 [4], and must be used in the RAs sent over the MR ingress interface for that prefix.

Mobile Network Prefix A 16 byte field contains the Mobile Network Prefix.

8. Mobile Router Operation

9. Home Agent Operation

10. Back End considerations

11. Security Considerations

12. IANA Considerations

The specification requires the following allocations from IANA:

The Mobile Network Prefix Request option described in Section 7.4 requires a new option type. This option is included in the Mobility header described in Mobile IPv6 [8] .

The Mobile Network Prefix Confirm option described in Section 7.5 requires a new option type. This option is included in the Mobility header described in Mobile IPv6 [8].

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