IETF 124 – 6lo

Generic Address Assignment Option for 6LoWPAN Neighbor Discovery

~~draft-ietf-6lo-nd-gaao-06~~

~~draft-ietf-6lo-nd-gaao-07~~

draft-ietf-6lo-nd-gaao-08

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IETF 124 – Montreal

Since IETF 123

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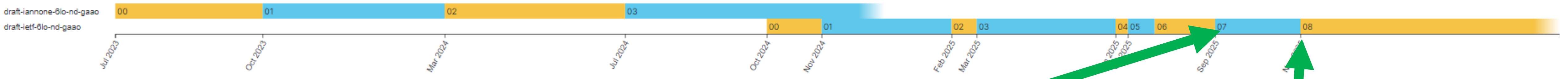
draft-ietf-6lo-nd-gaao-08

Status | IESG evaluation record | IESG writeups | Email expansions | History

Versions:

00 01 02 03 04 05 06 07 08



draft-ietf-6lo-nd-gaao-07.txt
September 2025
Main changes: Address Pascal's review to include prefix handling (thanks Pascal)

draft-ietf-6lo-nd-gaao-08.txt
November 2025
Main changes: Address shepherd's review (thanks Carles)

Main Changes -07: Structure

Minor Changes:

- Some section renaming
- Highlighted optimization in two sub-sections

Main Changes -07: Implicit vs Explicit registration

```
STEP
          6LN                        6LR
           |                          |
  1.       |  Address Request         | \
           | -----------------------> |  \
           |                          |   + Request Phase
  2.       |  Address Offer           |  /
           | <----------------------- | /
           |                          |
  3.       |  Address Acceptation     | \
           | -----------------------> |  \
           |                          |   + Optional Ratification Phase
  4.       |  Address Confirmation    |  /
           | <----------------------- | /
           |                          |

              Figure 1: Address/Prefix assignment sequence.
```

```
STEP
          6LN                          6LR/6LBR
           |                              |
  1.       |  Address/Prefix Request      | \
           | ---------------------------> |  \
           |                              |   + Request Phase
  2.       |  Address/Prefix Offer        |  /
           | <--------------------------- | /
           |                              |
  3.       |  Address/Prefix Acceptation  | \
           | ---------------------------> |  \
           |                              |   + Optional Explicit
  4.       |  Address/Prefix Confirmation |  /    Registration Phase
           | <--------------------------- | /
           |                              |

              Figure 1: Address/Prefix assignment sequence.
```

Went back from "ratification" to "registration"

1. Nodes send an explicit requests for an address/prefix to the chosen 6LR/6LBR.
2. The 6LR/6LBR assigns the address/prefix based on the AAF.
3. Depending on the specific technology and algorithm in use, the 6LR/6LBR will
   - implicitly register this assignment to the requesting 6LN
   - indicate to the 6LN that an explicit registration of the assigned address/prefix is necessary to confirm its use.

Main Changes -07: GAAO Format (I)

```
    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    | Status/PfxLen |    Opaque     |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |R|C|     Reserved      |  AAF  |     Assignment   Lifetime     |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                               |
   ~            Registration Ownership Verifier (ROVR)             ~
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                               |
   |                        Address/Prefix                         |
   |                          (128 bits)                           |
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

        Figure 2: Generic Address Assignment Option format.
```

R: 1-bit flag for Ratification requested. It MUST be initialized to 0 in NS(GAAO) messages by the requester and MUST be ignored by the receiver. The 6LR/6LBR replying to the request with an NA(GAAO) message MAY set this bit to indicate that it requests a confirmation that the address/prefix is accepted and will be used. When the requester receives an NA(GAAO) message with this bit set, it MUST explicitly register the received address/prefix to the same 6LR using the procedures defined in [RFC8505], [I-D.ietf-6lo-prefix-registration], and [RFC9685], according to the type of the assigned address/prefix.

C: 1-bit flag for Crypto-ID used for ROVR as defined [RFC8928] and [I-D.ietf-6lo-updating-rfc-8928]. This flag MUST be set when the ROVR field contains a Crypto-ID.

```
    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    |    Status     |    Opaque     |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |R|C|Rsvd |   PfxLen    |  AAF  |     Assignment   Lifetime     |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                               |
   ~            Registration Ownership Verifier (ROVR)             ~
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                               |
   |                        Address/Prefix                         |
   |                          (128 bits)                           |
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

        Figure 2: Generic Address Assignment Option (GAAO) format.
```

R: 1-bit flag for explicit Registration being requested. It MUST be initialized to 0 in Neighbor Solicitation (NS) message by the requester and MUST be ignored by the receiver. The 6LR/6LBR replying to the request with an Neighbor Advertisement (NA) message MAY set this bit to indicate that it requests a confirmation that the address/prefix is accepted and will be used. When the 6LR/6LBR sets the R-flag in a NA(GAAO) message, it indicates that no registration state has been created and that the requester MUST explicitly register the received address/prefix to the same 6LR using the procedures defined in [RFC8505], [I-D.ietf-6lo-prefix-registration], and [RFC9685], according to the type of the assigned address/prefix. When the 6LR/6LBR does not set this R-flag, it implicitly indicates that the assigned address/prefix has been also registered and state created as specified in [RFC8505], [I-D.ietf-6lo-prefix-registration], and [RFC9685], according to the type of the assigned address/prefix. In the event that the 6LN does not want to use the allocated address/prefix, it can de-register the allocation by sending an NS(EARO) setting registration lifetime to zero, as defined in [RFC8505].

C: 1-bit flag for Crypto-ID used for ROVR as defined [RFC8928] and [I-D.ietf-6lo-updating-rfc-8928]. This flag MUST be set when the ROVR field contains a Crypto-ID.

- R-flag stands (again) for "Registration"
- If set, it indicates that an explicit Registration is requested before using the assignment because the 6LR/6LBR did not create any registration state
- If not set, implicitly indicates that registration state has been created.
- If 6LN does not want to use the Address/Prefix it de-registers with an NS(EARO) with lifetime equal zero.

Main Changes -07: GAAO Format (II)

```
 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     |  Status/PfxLen |    Opaque    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|R|C|   Reserved        |  AAF  |     Assignment   Lifetime     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
~            Registration Ownership Verifier (ROVR)             ~
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
|                        Address/Prefix                         |
|                          (128 bits)                           |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

      Figure 2: Generic Address Assignment Option 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |    Length     |    Status     |    Opaque     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|R|C|Rsvd|    PfxLen    |  AAF  |     Assignment   Lifetime     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
~            Registration Ownership Verifier (ROVR)             ~
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
|                        Address/Prefix                         |
|                          (128 bits)                           |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

   Figure 2: Generic Address Assignment Option (GAAO) format.
```

PfxLen: 7-bit unsigned integer. It indicates the length of the prefix in bits.

Address/Prefix: 128-bit IPv6 address/prefix. This field MAY be present in NS(GAAO) request messages to indicate the prefix from which the address or sub-prefix has to be derived. If not present in NS(GAAO) message, it means that the returned address is implicitly used on the interface used to send the request. This field MUST be present in NA(GAAO) message that return a successful address/prefix allocation, but MUST NOT be present in case of error.

- In order to handle prefixes a 7-bit field indicating the prefix length has been added
- Address/Prefix field MAY be now present in NS(GAAO) messages to indicate from which prefix to assign the address or sub-prefix
- In NA(GAAO) messages it indicates actual length of the prefix

Main Changes -07: Optimization Clarification

```
5.3.  Message Exchange Optimization

   Prefix/address requests utilize NS/NA transactions, similar to
   prefix/address registration.  To minimize the number of transactions
   GAAO MAY be used at the same time like the EARO option.  In other
   words GAAO can be piggybacked on other transactions, hence it does
   not necessarily introduce additional NS/NA transactions.  For
   instance, it can be piggybacked in an link-layer address
   registration, as shown in Figure 5.  In this case the returning
   NA(GAAO+EARO) will contain an address directly appended in GAAO,
   namely the offered prefix/address.

   STEP
           6LN                                        6LR
            |                                          |
     1.     | ----- NS with Address Registration ----> |
            |       (EARO + SLLAO + TLLAO + GAAO)      |
            |                                          |
     2.     | <---- NA with Address Registration  ---- |
            |     (EARO with Status + SLLAO + GAAO)    |
            |                                          |

    Figure 5: Message sequence when GAAO is piggybacked on a link-layer
                         registration transaction.
```

```
5.3.  Message Exchange Optimization

   There are two ways to optimize the prefix/address Request Phase

5.3.1.  GAAO with Address Registration

   Prefix/address registration utilize NS/NA transactions for the link-
   local address registration [RFC8505].  In this specification, for
   prefix/address Request procedure utilize an additional NS/NA
   transactions.  To minimize the number of transactions, GAAO MAY be
   used together with the EARO option during address registration phase.
   This piggybacking approach provides flexibility and maintains
   compatibility with existing specifications [RFC8505].  In response
   the NA message will contain GAAO.  Figure 5 illustrates the GAAO
   piggybacked within a link-layer address registration request and
   response.

   STEP

           6LN                                        6LR/6LBR
            |                                          |
            |      Address Registration Request        |
     1.     | ---------------------------------------> |
            |         NS(EARO + SLLAO + GAAO)          |
            |                                          |
            |      Address Registration Response       |
     2.     | <--------------------------------------- |
            |    NA(EARO with Status + SLLAO + GAAO)   |
            |                                          |
```

Better separate the two possible optimization for messages exchange:

- Piggyback GAAO in an address registration exchange (e.g. when registering a link-local address)
- Piggyback GAAO in RS/RA exchange
  - If not supported RA will not contain GAAO

Main Changes -08: Lots of text improvement

```
*PfxLen:*  7-bit unsigned integer.  It indicates the length of the
   prefix in bits.
```

```
*PfxLen:*  7-bit unsigned integer.  It indicates the length in bits
   of the address/prefix carried in the option.
```

```
*Address/Prefix:*  128-bit IPv6 address/prefix.  This field MAY be
   present in NS(GAAO) request messages to indicate the prefix from
   which the address or sub-prefix has to be derived.  If not present
   in NS(GAAO) message, it means that the returned address is
   implicitly used on the interface used to send the request.  This
   field MUST be present in NA(GAAO) message that return a successful
   address/prefix allocation, but MUST NOT be present in case of
   error.
```

```
*Address/Prefix:*  128-bit IPv6 address/prefix.  This field MAY be
   present in NS(GAAO) request messages to indicate the prefix from
   which the address or sub-prefix has to be derived.  If not present
   in an NS(GAAO) message, it means that the address returned in an
   NA(GAAO) message is implicitly used on the interface used to send
   the request.  This field MUST be present in NA(GAAO) messages that
   return a successful address/prefix allocation, but MUST NOT be
   present in case of error.  When the field is used return a prefix,
   the leftmost bits are used for its encoding according to the
   length field, the remaining bits are set to zero.
```

```
5.3.  Message Exchange Optimization

   There are two ways to optimize the prefix/address Request Phase
```

```
5.3.  Message Exchange Optimization

   There are two ways to optimize the prefix/address Request Phase: GAAO
   with Address Registration and GAAO with Router Discovery.
```

```
Acknowledgements

   This document received many comments and help from community people.
   The authors would like to thank all of them.  Thanks as well to Joel
   Halpern (GENART) and Brian Haberman (INTDIR) for their reviews that
   helped to spot overlooked points in the definition of the GAAO
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   Halpern (GENART) and Brian Haberman (INTDIR) for their reviews that
   helped to spot overlooked points in the definition of the GAAO
   mechanism.  Thanks to Pascal Thubert for his help in making this
   specification more integrated with existing specifications.  Thanks
   ez Montenegro for his very thorough shepherd review.
```

```
1.  Introduction

   Low Power and Lossy Networks (LLNs) have adapted the design of
   Internet protocols to more constrained environments, by taking into
   consideration of energy saving, limited memory capacity, and duty
   cycling of the LLN devices, as well as low-power lossy transmissions.
   Since the wireless interface is a major energy drain, protocols
   aiming at being deployed over LLN must be designed in such a way to
   reduce as much as possible transmissions, allowing to turn off the
   radio interface or put the interface or the whole node in the
   sleeping mode.

   IPv6 Neighbor Discovery has been also adapted to the LLN environment
   in [RFC6775], later updated by [RFC8505], [RFC8929], and [RFC9010].
   The target being to design protocols that reduce energy consumption,
   especially in LLNs, though in general their design could be applied
   in any context targeting lowering carbon emissions.  In particular,
   interface address assignment relies on address auto-configuration
   (such as Stateless Address Autoconfiguration (SLAAC)[RFC4862]), since
   the use of Dynamic Host Configuration Protocol (DHCP [RFC8415]) is
```

```
1.  Introduction

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   of Internet protocols to more constrained environments, by taking
   into consideration energy saving, limited memory capacity, and duty
   cycling of the LLN devices, as well as low-power and lossy
   transmissions.  Since the wireless interface is a major energy drain,
   protocols aiming at being deployed over LLNs must be designed in such
   a way to reduce as much as possible transmissions and idle listening,
   allowing to turn off the radio interface or put the interface or the
   whole node in the sleeping mode.

   IPv6 Neighbor Discovery has been also adapted to the LLN environment
   in [RFC6775], later updated by [RFC8505], [RFC8929], and [RFC9010].
   The target has been to design protocols that reduce energy
   consumption, especially in LLNs, though in general their design could
   be applied in any context targeting lowering carbon emissions.  In
   particular, interface address assignment relies on address auto-
   configuration (such as Stateless Address Autoconfiguration
   (SLAAC)[RFC4862]), since the use of Dynamic Host Configuration
```

Next Steps

- Early reviews
  - INTDIR: OK
  - GENART: OK
- Chairs/Shepherd: OK

THANKS!