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IPv6 RA Options for Next Hop Routes
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Abstract

This proposes an update on RFC 4191 in order to define new Router Advertisement options for configuring next hop routes on the mobile or fixed nodes. Using these options, an operator can easily configure nodes with multiple interfaces (or otherwise multi-homed) to enable them to select the routes to a destination. Each option is defined together with definitions of host and router behaviors.

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1. Introduction

IPv6 Neighbor Discovery and IPv6 Stateless Address Autoconfiguration protocols can be used to configure fixed and mobile nodes with various parameters related to addressing and routing [RFC4861], [RFC4862], [RFC4191]. DNS Recursive Server Addresses and Domain Name Search Lists are additional parameters that can be configured using router advertisements [RFC6106].

Router Advertisements can also be used to configure fixed and mobile nodes in multi-homed scenarios with route information and next hop address. Different scenarios exist such as the node is simultaneously connected to multiple access network of e.g. WiFi and 3G. The node may also be connected to more than one gateway. Such connectivity may be realized by means of dedicated physical or logical links that may also be shared with other users nodes such as in residential access networks.

2. Terminology

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].

3. Default Route Configuration

A host, usually a mobile host interested in obtaining routing information usually sends a Router Solicitation (RS) message on the link. The router, when configured to do so, provides the route information using zero, one or more Next Hop Address and Route Information options in the router advertisement (RA) messages sent in response.

The route options are extensible, as well as convey detailed information for routes.

RS and RA exchange is for next hop address and route information determination and not for determining the link-layer address of the router. Subsequent Neighbor Solicitation and Neighbor Advertisement exchange can be used to determine link-layer address of the router.

It should be noted that the proposed options in this document will need a central site-wide configuration mechanism. The required values can not automatically be derived from routing tables.

Next hop address and related route information may be provided by some other means such as directly by the next hop routers. In this document we assume that next hop routers are not able to provide this information. One solution would be to develop an inter-router protocol to instigate the next hop routers to provide this information. However, such a solution has been singled out due to the complexities involved.

A non-trustworthy network may be available at the same time as a trustworthy network, with the risk of bad consequences if the host gets confused between the two. These are basically the two models for hosts with multiple interfaces, both of which are valid, but which are incompatible with each other. In the first model, an interface is connected to something like a corporate network, over a Virtual Private Network (VPN). This connection is trusted because it has been authenticated. Routes obtained over such a connection can probably be trusted, and indeed it may be important to use those routes. This is because in the VPN case, you may also be connected to a network that's offered you a default route, and you could be attacked over that connection if you attempt to connect to resources on the enterprise network over it.

On the other, non-trustworthy network scenario, none of the networks to which the host is connected are meaningfully more or less trustworthy. In this scenario, the untrustworthy network may hand out routes to other hosts, e.g. those in the VPN going through some malicious nodes. This will have bad consequences because the host's

traffic intended for the corporate VPN may be hijacked by the intermediate nodes.

Router advertisement extensions described in this document can be used to install the routes. However, the use of such a technique makes sense only in the former case above, i.e. trusted network. So the host MUST have an authenticated connection to the network it connects so that the router advertisements can be trusted before establishing routes.

4. Source Address Dependent Routing

In multihomed networks there is a need to do source address based routing if some providers are performing the ingress filtering defined in BCP38 [RFC2827]. This requires the routers to consider the source addresses as well as the destination addresses in determining the next hop to send the packet to.

The routers may be informed about the source addresses to use in routing using extensions to the routing protocols like IS-IS defined in [ISO.10589.1992] [I-D.baker-ipv6-isis-dst-src-routing] and OSPF defined in [RFC5340] [I-D.baker-ipv6-ospf-dst-src-routing]. In this document we define the router advertisement extensions for source address dependent routing.

Routing protocol extensions for source address dependent routing does not avoid a host using a source address that may be subject to ingress filtering when sending a packet to one of the next hops. In that case the host receives an ICMP source address failed ingress/ egress policy eroor message in which case the host must resend the packet trying a different source address. The extensions defined in this document aims at avoiding this inefficiency in packet forwarding at the host.

5. Host Configuration

Router advertisement options defined in this document are used by Type C hosts.

As defined in [RFC4191] Type C host uses a Routing Table instead of a Default Router List.

The hosts set up their routing tables based on the router advertisement extensions defined in this document.The routes established are used in forwarding the packets to a next hop based on the destination prefix/address using the longest match algorithm.

In case the host receives Next Hop Address with Source Address and Route Prefix option, the host uses source and destination prefix/ address using the longest match algorithm in order to select the next hop to forward the packet to.

6. Router Configuration

The router MAY send one or more Next Hop Address options that specify the IPv6 next hop addresses. Each Next Hop Address option may be associated with zero, one or more Route Prefix options that represent the IPv6 destination prefixes reachable via the given next hop. Router includes Route Prefix option in message to indicate that given prefix is available directly on- link.

Router MAY send a single Next Hop Address without any Route Prefix options. When router sends Next Hop Address option that is associated with Router Prefix option, the router MUST use Next Hop and Route Prefix option defined in Section 11. The Route Prefix MAY contain ::/0, i.e. with Prefix Length set to zero to indicate available default route.

The router MAY send one or more Next Hop Address options that specify the IPv6 next hop addresses and source address. Each Next Hop Address option may be associated with zero, one or more Source Address options that represent the source addresses that are assigned from the prefixes that belong to this next hop defined in Section 13. In addition, the option MAY contain Route Prefix options that represent the IPv6 destination prefixes reachable via the given next hop. Router includes Source Address option and Route Prefix option in the message to indicate that given prefix is available directly on- link and that the source address will not be subject to ingress filtering.

The router MAY send one or more Next Hop Address options that specify the IPv6 next hop addresses and source address. Each Next Hop Address option may be associated with zero, one or more Source Prefix options that represent the source addresses that are assigned from the prefixes that belong to this next hop defined in Section 12. In addition, the option MAY contain Route Prefix options that represent the IPv6 destination prefixes reachable via the given next hop. Router includes Source Prefix option and Route Prefix option in the message to indicate that given prefix is available directly on- link and that any source addresses derived from the source prefix will not be subject to ingress filtering on these routes supported by these next hops.

7. Route Prefix option

```
    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 |Resvd|Prf|Metric|
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                         Route Lifetime                        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                   Prefix (Variable Length)                    |
   .                                                               .
   .                                                               .
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1: Route Prefix option

Fields:

Type: TBD.

Length: The length of the option (including the Type and Length fields) in units of 8 octets.

Other fields are as in [RFC4191] except:

Metric Route Metric. 3-bit signed integer. The Route Metric indicates whether to prefer the next hop associated with this prefix over others, when multiple identical prefixes (for different next hops) have been received.

8. Next Hop Address option

```
     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     |    Next Hop Address ...
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 2: Next Hop Address option

Fields:

Type: TBD.

Length: The length of the option (including the type and length fields) in units of 8 octets. It's value is 3.

Next Hop Address: An IPv6 address that specifies IPv6 address of the next hop. It is 16 octets in length.

9. Source Address option

```
 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     |    Source Address ...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 3: Source Address option

Fields:

Type: TBD.

Length: The length of the option (including the type and length fields) in units of 8 octets. It's value is 3.

Source Address: An IPv6 address that specifies the source IPv6 address. It is 16 octets in length.

10. Source Prefix option

```
 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|  Prefix ...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4: Source Prefix option

Fields:

Type: TBD.

Length: The length of the option (including the type and length fields) in units of 8 octets. It's value is 3.

Prefix Length: An IPv6 prefix length in bits, from 0 to 128.

Prefix: An IPv6 prefix that specifies the source IPv6 prefix. It is 16 octets or less in length.

11. Next Hop Address with Route Prefix option

```
 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     |    Next Hop Address ...       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
+                            ...                                +
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                 ...           | Prefix Length |Resvd|Prf|Metric|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Route Lifetime                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   Prefix (Variable Length)                    |
.                                                               .
.                                                               .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5: Next Hop Address with Route Prefix option

Fields:

Type: TBD.

Length: The length of the option (including the type and length fields) in units of 8 octets. For example, the length for a prefix of length 16 is 5.

Other fields are as in Section 7 and Section 8.

12. Next Hop Address with Source Prefix and Route Prefix option

```
    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     |    Next Hop Address ...       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   +                             ...                               +
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                 ...           |        Source Prefix          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   +                             ...                               +
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                 ...           | Prefix Length |Resvd|Prf|Metric|
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                         Route Lifetime                        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                    Prefix (Variable Length)                   |
   .                                                               .
   .                                                               .
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 6: Next Hop Address with Source Prefix and Route Prefix option

Fields:

Type: TBD.

Length: The length of the option (including the type and length fields) in units of 8 octets. For example, the length for a prefix of length 16 is 5.

Other fields are as in Section 7, Section 8 and Section 10.

13. Next Hop Address with Source Address and Route Prefix option

```
 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     |    Next Hop Address ...       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
+                            ...                                +
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                 ...           |        Source Address         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
+                            ...                                +
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                 ...           | Prefix Length |Resvd|Prf|Metric|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Route Lifetime                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   Prefix (Variable Length)                    |
.                                                               .
.                                                               .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 7: Next Hop Address with Source Address and Route Prefix option

Fields:

Type: TBD.

Length: The length of the option (including the type and length fields) in units of 8 octets. For example, the length for a prefix of length 16 is 5.

Other fields are as in Section 7, Section 8 and Section 9.

14. Security Considerations

Neighbor Discovery is subject to attacks that cause IP packets to flow to unexpected places. Because of this, neighbor discovery messages MUST be secured, possibly using Secure Neighbor Discovery (SEND) protocol [RFC3971].

15. IANA Considerations

Authors of this document request IANA to assign the following new RA options:

Option Name	Type
Route Prefix	
Next Hop Address	
Source Address	
Source Prefix	
Next Hop Address and Route Prefix	
Next Hop Address with Source Address and Route Prefix	
Next Hop Address with Source Prefix and Route Prefix	

Table 1:

16. Acknowledgements

TBD.

17. References

17.1. Normative References

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17.2. Informative References

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