                     Multiprotocol Extensions for BGP-4

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Abstract

   Currently BGP-4 [BGP-4] is capable of carrying routing information
   only for IPv4 [IPv4]. This document defines extensions to BGP-4 to
   enable it to carry routing information for multiple Network Layer
   protocols (e.g., IPv6, IPX, etc...). The extensions are backward
   compatible - a router that supports the extensions can interoperate
   with a router that doesn't support the extensions.

   This document obsoletes RFC 2283.

1. Overview

   The only three pieces of information carried by BGP-4 that are IPv4
   specific are (a) the NEXT_HOP attribute (expressed as an IPv4
   address), (b) AGGREGATOR (contains an IPv4 address), and (c) NLRI
   (expressed as IPv4 address prefixes). This document assumes that any
   BGP speaker (including the one that supports multiprotocol
   capabilities defined in this document) has to have an IPv4 address
   (which will be used, among other things, in the AGGREGATOR
   attribute). Therefore, to enable BGP-4 to support routing for
   multiple Network Layer protocols the only two things that have to be
   added to BGP-4 are (a) the ability to associate a particular Network
   Layer protocol with the next hop information, and (b) the ability to

associated a particular Network Layer protocol with NLRI. To identify individual Network Layer protocols this document uses Address Family, as defined in [RFC1700].

One could further observe that the next hop information (the information provided by the NEXT_HOP attribute) is meaningful (and necessary) only in conjunction with the advertisements of reachable destinations - in conjunction with the advertisements of unreachable destinations (withdrawing routes from service) the next hop information is meaningless. This suggests that the advertisement of reachable destinations should be grouped with the advertisement of the next hop to be used for these destinations, and that the advertisement of reachable destinations should be segregated from the advertisement of unreachable destinations.

To provide backward compatibility, as well as to simplify introduction of the multiprotocol capabilities into BGP-4 this document uses two new attributes, Multiprotocol Reachable NLRI (MP_REACH_NLRI), and Multiprotocol Unreachable NLRI (MP_UNREACH_NLRI). The first one (MP_REACH_NLRI) is used to carry the set of reachable destinations together with the next hop information to be used for forwarding to these destinations. The second one (MP_UNREACH_NLRI) is used to carry the set of unreachable destinations. Both of these attributes are optional and non-transitive. This way a BGP speaker that doesn't support the multiprotocol capabilities will just ignore the information carried in these attributes, and will not pass it to other BGP speakers.

2. Multiprotocol Reachable NLRI - MP_REACH_NLRI (Type Code 14):

This is an optional non-transitive attribute that can be used for the following purposes:

    (a) to advertise a feasible route to a peer

    (b) to permit a router to advertise the Network Layer address of the router that should be used as the next hop to the destinations listed in the Network Layer Reachability Information field of the MP_NLRI attribute.

    (c) to allow a given router to report some or all of the Subnetwork Points of Attachment (SNPAs) that exist within the local system

The attribute is encoded as shown below:

```
+---------------------------------------------------------+
| Address Family Identifier (2 octets)                    |
+---------------------------------------------------------+
| Subsequent Address Family Identifier (1 octet)          |
+---------------------------------------------------------+
| Length of Next Hop Network Address (1 octet)            |
+---------------------------------------------------------+
| Network Address of Next Hop (variable)                  |
+---------------------------------------------------------+
| Number of SNPAs (1 octet)                               |
+---------------------------------------------------------+
| Length of first SNPA(1 octet)                           |
+---------------------------------------------------------+
| First SNPA (variable)                                   |
+---------------------------------------------------------+
| Length of second SNPA (1 octet)                         |
+---------------------------------------------------------+
| Second SNPA (variable)                                  |
+---------------------------------------------------------+
| ...                                                     |
+---------------------------------------------------------+
| Length of Last SNPA (1 octet)                           |
+---------------------------------------------------------+
| Last SNPA (variable)                                    |
+---------------------------------------------------------+
| Network Layer Reachability Information (variable)       |
+---------------------------------------------------------+
```

The use and meaning of these fields are as follows:

Address Family Identifier:

   This field carries the identity of the Network Layer protocol
   associated with the Network Address that follows. Presently
   defined values for this field are specified in RFC 1700 (see
   the Address Family Numbers section).

Subsequent Address Family Identifier:

   This field provides additional information about the type of
   the Network Layer Reachability Information carried in the
   attribute.

   Length of Next Hop Network Address:

      A 1 octet field whose value expresses the length of the
      "Network Address of Next Hop" field as measured in octets

   Network Address of Next Hop:

      A variable length field that contains the Network Address of
      the next router on the path to the destination system

   Number of SNPAs:

      A 1 octet field which contains the number of distinct SNPAs to
      be listed in the following fields. The value 0 may be used to
      indicate that no SNPAs are listed in this attribute.

   Length of Nth SNPA:

      A 1 octet field whose value expresses the length of the "Nth
      SNPA of Next Hop" field as measured in semi-octets

   Nth SNPA of Next Hop:

      A variable length field that contains an SNPA of the router
      whose Network Address is contained in the "Network Address of
      Next Hop" field. The field length is an integral number of
      octets in length, namely the rounded-up integer value of one
      half the SNPA length expressed in semi-octets; if the SNPA
      contains an odd number of semi-octets, a value in this field
      will be padded with a trailing all-zero semi-octet.

   Network Layer Reachability Information:

      A variable length field that lists NLRI for the feasible routes
      that are being advertised in this attribute. When the
      Subsequent Address Family Identifier field is set to one of the
      values defined in this document, each NLRI is encoded as
      specified in the "NLRI encoding" section of this document.

   The next hop information carried in the MP_REACH_NLRI path attribute
   defines the Network Layer address of the border router that should be
   used as the next hop to the destinations listed in the MP_NLRI
   attribute in the UPDATE message. When advertising a MP_REACH_NLRI
   attribute to an external peer, a router may use one of its own
   interface addresses in the next hop component of the attribute,
   provided the external peer to which the route is being advertised
   shares a common subnet with the next hop address. This is known as a
   "first party" next hop. A BGP speaker can advertise to an external

peer an interface of any internal peer router in the next hop
component, provided the external peer to which the route is being
advertised shares a common subnet with the next hop address. This is
known as a "third party" next hop information. A BGP speaker can
advertise any external peer router in the next hop component,
provided that the Network Layer address of this border router was
learned from an external peer, and the external peer to which the
route is being advertised shares a common subnet with the next hop
address. This is a second form of "third party" next hop
information.

Normally the next hop information is chosen such that the shortest
available path will be taken. A BGP speaker must be able to support
disabling advertisement of third party next hop information to handle
imperfectly bridged media or for reasons of policy.

A BGP speaker must never advertise an address of a peer to that peer
as a next hop, for a route that the speaker is originating. A BGP
speaker must never install a route with itself as the next hop.

When a BGP speaker advertises the route to an internal peer, the
advertising speaker should not modify the next hop information
associated with the route. When a BGP speaker receives the route via
an internal link, it may forward packets to the next hop address if
the address contained in the attribute is on a common subnet with the
local and remote BGP speakers.

An UPDATE message that carries the MP_REACH_NLRI must also carry the
ORIGIN and the AS_PATH attributes (both in EBGP and in IBGP
exchanges). Moreover, in IBGP exchanges such a message must also
carry the LOCAL_PREF attribute. If such a message is received from an
external peer, the local system shall check whether the leftmost AS
in the AS_PATH attribute is equal to the autonomous system number of
the peer than sent the message. If that is not the case, the local
system shall send the NOTIFICATION message with Error Code UPDATE
Message Error, and the Error Subcode set to Malformed AS_PATH.

An UPDATE message that carries no NLRI, other than the one encoded in
the MP_REACH_NLRI attribute, should not carry the NEXT_HOP attribute.
If such a message contains the NEXT_HOP attribute, the BGP speaker
that receives the message should ignore this attribute.

3. Multiprotocol Unreachable NLRI - MP_UNREACH_NLRI (Type Code 15):

This is an optional non-transitive attribute that can be used for the
purpose of withdrawing multiple unfeasible routes from service.

The attribute is encoded as shown below:

```
+---------------------------------------------------------+
| Address Family Identifier (2 octets)                    |
+---------------------------------------------------------+
| Subsequent Address Family Identifier (1 octet)          |
+---------------------------------------------------------+
| Withdrawn Routes (variable)                             |
+---------------------------------------------------------+
```

The use and the meaning of these fields are as follows:

Address Family Identifier:

This field carries the identity of the Network Layer protocol associated with the NLRI that follows. Presently defined values for this field are specified in RFC 1700 (see the Address Family Numbers section).

Subsequent Address Family Identifier:

This field provides additional information about the type of the Network Layer Reachability Information carried in the attribute.

Withdrawn Routes:

A variable length field that lists NLRI for the routes that are being withdrawn from service. When the Subsequent Address Family Identifier field is set to one of the values defined in this document, each NLRI is encoded as specified in the "NLRI encoding" section of this document.

An UPDATE message that contains the MP_UNREACH_NLRI is not required to carry any other path attributes.

4. NLRI encoding

The Network Layer Reachability information is encoded as one or more 2-tuples of the form <length, prefix>, whose fields are described below:

```
+--------------------------+
|    Length (1 octet)      |
+--------------------------+
|    Prefix (variable)     |
+--------------------------+
```

The use and the meaning of these fields are as follows:

   a) Length:

      The Length field indicates the length in bits of the address
      prefix. A length of zero indicates a prefix that matches all
      (as specified by the address family) addresses (with prefix,
      itself, of zero octets).

   b) Prefix:

      The Prefix field contains an address prefix followed by enough
      trailing bits to make the end of the field fall on an octet
      boundary. Note that the value of trailing bits is irrelevant.

5. Subsequent Address Family Identifier

   This document defines the following values for the Subsequent Address
   Family Identifier field carried in the MP_REACH_NLRI and
   MP_UNREACH_NLRI attributes:

      1 - Network Layer Reachability Information used for unicast
          forwarding

      2 - Network Layer Reachability Information used for multicast
          forwarding

      3 - Network Layer Reachability Information used for both unicast
          and multicast forwarding

6. Error Handling

   If a BGP speaker receives from a neighbor an Update message that
   contains the MP_REACH_NLRI or MP_UNREACH_NLRI attribute, and the
   speaker determines that the attribute is incorrect, the speaker must
   delete all the BGP routes received from that neighbor whose AFI/SAFI
   is the same as the one carried in the incorrect MP_REACH_NLRI or
   MP_UNREACH_NLRI attribute. For the duration of the BGP session over
   which the Update message was received, the speaker then should ignore
   all the subsequent routes with that AFI/SAFI received over that
   session.

   In addition, the speaker may terminate the BGP session over which the
   Update message was received. The session should be terminated with
   the Notification message code/subcode indicating "Update Message
   Error"/"Optional Attribute Error".

7. Use of BGP Capability Advertisement

   A BGP speaker that uses Multiprotocol Extensions should use the
   Capability Advertisement procedures [BGP-CAP] to determine whether
   the speaker could use Multiprotocol Extensions with a particular
   peer.

   The fields in the Capabilities Optional Parameter are set as follows.
   The Capability Code field is set to 1 (which indicates Multiprotocol
   Extensions capabilities). The Capability Length field is set to 4.
   The Capability Value field is defined as:

      The use and meaning of this field is as follow:

```
                    0       7      15      23      31
                    +-------+-------+-------+-------+
                    |      AFI      | Res.  | SAFI  |
                    +-------+-------+-------+-------+
```

         AFI - Address Family Identifier (16 bit), encoded the same way
                as in the Multiprotocol Extensions

         Res. - Reserved (8 bit) field. Should be set to 0 by the sender
                and ignored by the receiver.

         SAFI - Subsequent Address Family Identifier (8 bit), encoded
                the same way as in the Multiprotocol Extensions.

   A speaker that supports multiple <AFI, SAFI> tuples includes them as
   multiple Capabilities in the Capabilities Optional Parameter.

   To have a bi-directional exchange of routing information for a
   particular <AFI, SAFI> between a pair of BGP speakers, each such
   speaker must advertise to the other (via the Capability Advertisement
   mechanism) the capability to support that particular <AFI, SAFI>
   routes.

8. IANA Considerations

   As specified in this document, the MPL_REACH_NLRI and MP_UNREACH_NLRI
   attributes contain the Subsequence Address Family Identifier (SAFI)
   field. The SAFI name space is defined in Section 9. The IANA will
   maintain and register values for the SAFI namespace as follows. SAFI
   value 0 is reserved. SAFI values 1, 2, and 3 are assigned in this
   document. SAFI values 4 through 63 are to be assigned by IANA using
   the "IETF Consensus" policy defined in RFC 2434. SAFI values 64
   through 127 are to be assigned by IANA, using the "First Come First

   Served" policy defined in RFC 2434. SAFI values 128 through 255 are
   for "private use", and values in this range are not to be assigned by
   IANA.

9. Comparison with RFC 2283

   This document restricts the MP_REACH_NLRI attribute to carry only a
   single instance of <AFI, SAFI, Next Hop Information, ...>.

   This document restricts the MP_UNREACH_NLRI attribute to carry only a
   single instance of <AFI, SAFI, ...>.

   This document clarifies handling of an UPDATE message that carries no
   NLRI, other than the one encoded in the MP_REACH_NLRI attribute.

   This document clarifies error handling in the presence of
   MP_REACH_NLRI or MP_UNREACH_NLRI attributes.

   This document specifies the use of BGP Capabilities Advertisements in
   conjunction with Multi-protocol extensions.

   Finally, this document includes the "IANA Consideration" Section.

10. Security Considerations

   This extension to BGP does not change the underlying security issues
   inherent in the existing BGP [Heffernan].

11. Acknowledgements

   The authors would like to thank members of the IDR Working Group for
   their review and comments.

12. References

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   [RFC1700]   Postel, J. and J. K. Reynolds, "Assigned Numbers", STD
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Acknowledgement