Multicast Traceroute for MVPNs
draft-kebler-kurapati-l3vpn-mvpn-mtrace-01

Abstract

   Mtrace is a tool used to troubleshoot issues in a network deploying
   Multicast service. When multicast is used within a VPN service
   offering, the base Mtrace specification does not detect the failures.
   This document specifies a method of using multicast traceroute in a
   network offering Multicast in VPN service.

Status of This Memo

   This Internet-Draft is submitted in full conformance with the
   provisions of BCP 78 and BCP 79.

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   time. It is inappropriate to use Internet-Drafts as reference
   material or to cite them other than as "work in progress."

   This Internet-Draft will expire on January 5, 2015.

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1. Introduction

The current multicast traceroute [I-D.ietf-mboned-mtrace-v2] travels
up the tree hop-by-hop towards the source. This verifies the basic
multicast state back to the source, but is not sufficient to verify
the MVPN state. The base Mtrace specification assumes that the
routers in the path are directly connected through interfaces. In
the case of Multicast traffic over VPN service, the PEs who are MVPN
neighbors may be separated by several router hops. The path taken by
the query can be completely different from the path taken through
core by the actual multicast traffic. Consider a case in the below
figure, where provider tunnel between PE2 (Source) and PE1 (Receiver)
is not established correctly due to incorrect MVPN state on PE2. In
the current form of Mtrace, the Query would result in a successful
response since there is no error detection mechanism for MVPN state
available currently. Even if one can infer from the statistics of

the Mtrace Response that PE2 has an issue, the existing error codes
are not sufficient to identify the root cause. Also, there could be
a problem sending traffic over the provider tunnel from PE2 to PE1,
but the mtrace query will not even travel over this provider tunnel.
Therefore, the mtrace successful response can be misleading. This
draft ensures that the Response uses same provider-tunnel that the
given C-S,C-G data would traverse and returns appropriate MVPN
specific error codes which would help in identifying the root cause.

```
                                 xxxxxx
                        xxxxxxxxxxx    xxxx       +-----+
                          xxx                xxx    |     |   +---+
                           xx                      xx+-+ PE2 +---+CE2|
          +-----+    xx                        xx|     |   +---+
    +---+  |     |   x        Provider          x+-----+
    |CE1+---+ PE1 +--+x         Core            xxxx
    +---+  |     |   x                          xx
          +-----+   xx                        xxx  +----+
                     xxx                        x+-+    |   +---+
                      xxxxxxx        xxxxxxxxxxx  | PE3+---+CE3|
                         xx      xx               |    |   +---+
                         xxxxxxxx                 +----+
```
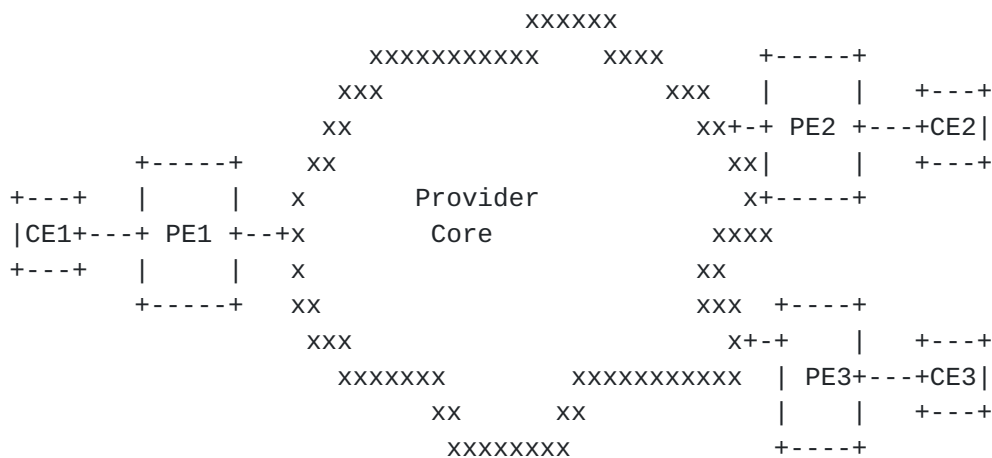
                            MVPN topology

2. Overview

   As described in the Mtracev2 specification
   [I-D.ietf-mboned-mtrace-v2], a Querier initiates an Mtrace Query
   which is sent to the Last Hop Router. Last Hop Router converts this
   into a Request and sends it towards the First Hop Router. This draft
   introduces a new "Downstream Request" mechanism to allow the First
   Hop Router to send the mtrace request message back on the Provider
   tunnel to the Last hop router. The last hop router will then change
   it to Response and send it to the Querier who initiated the Query.
   If there is any error encountered by the Last hop router or First Hop
   router, a Response is directly unicasted to the querier with
   appropriate MVPN specific error codes added. Each hop in the path of
   Mtrace decrements the TTL value before sending the mtrace message.

   Since the Mtrace is being extended for MVPNs, the Last Hop router and
   First Hop router SHOULD be a Provider Edge (PE) router so that the
   MVPN specific error codes can be contained within the provider space.
   The Request will be initiated by the egress PE and will travel
   upstream to the ingress PE. It is assumed that the Querier knows and

can reach the egress PE. A Querier and egress PE can be the same
router.

For Mtrace initiated by the CEs, the specification mentioned in
Mtracev2 [I-D.ietf-mboned-mtrace-v2] SHOULD be followed. If a Mtrace
message is received by the PE on CE facing interfaces containing MVPN
specific extensions defined in this draft, it SHOULD be discarded.

3. Protocol Details

The protocol details that follow are described in terms of mtracev2.
However, the same procedures can be achieved with mtracev1. The
protocol extensions needed for mtracev2 are described in Section 5
and the protocol extensions for mtracev1 and described in section 6.

3.1. Mtrace Query

A Querier willing to perform a Mtrace on a MVPN issues a Mtrace
Query. The format of the Query TLV is as specified in the Mtracev2
specification [I-D.ietf-mboned-mtrace-v2]. The (C-S,C-G) to be
queried is populated in the source address and group address fields
of the Mtrace2 Query block. A deployment may use wild card SPMSIs as
defined in [RFC6625]. For example, a (C-*,C-*) wild card SPMSI or a
(C-*,ALL-PIM-ROUTERS) can be used to send messages like BSR across
PEs as mentioned in section 5.3.4 MVPN specification [RFC6513]. A
querier may be interested in knowing the health of such a SPMSI
tunnel. In this case, the Multicast Address and Source Address
fields of the Mtrace2 query can be filled with wild cards (all 1s)
accordingly by the querier.

The Querier MUST add a MVPN Extended Query Block to include the RD of
the C-S,C-G that it wishes to trace. When wild card SPMSIs are used,
a PE could have subscribed to multiple upstream PEs for wild card
SPMSIs. Hence, a query for a wild card SPMSI MUST also specify the
upstream PE address that it is interested to query. The upstream PE
address in the MVPN Extended Query Block MUST be filled only for wild
card queries. For a regular (C-S,C-G) query, this field SHOULD be
set to 0s by the querier and is ignored by the receivers.

This Query is sent to the Downstream PE (Last Hop Router)to initiate
the mtrace towards the source. If a Querier does not receive a
Response, it can retry sending Query messages with increasing TTL
values to help diagnose where the Mtrace messages are being lost.

3.2. **Mtrace Request**

   The PE that receives the query will lookup the (C-S,C-G) using the RD
   of the query to distinguish the vrf. If the RD doesnt match any VRF,
   PE sends a response with error code set to BAD_RD. The PE first
   checks the C-Mcast route that is matching (C-S,C-G) of the mtrace
   Query. It then finds the upstream multicast hop from the selected
   C-Mcast route and unicasts the requests to the upstream multicast hop
   after decrementing the TTL. The Mtrace Request MUST have PMSI Tunnel
   Attributes Augmented Response Block populated with the PMSI attribute
   that the PE uses to receive the traffic for the given (C-S,C-G)
   traffic.

   Upstream multicast hop can be same as upstream PE router in some
   cases, while it can be the ASBR or the BGP nexthop of the selected
   C-Mcast route in Inter-AS scenarios. The procedures for finding
   upstream multicast hop is discussed in detail under section 5.1 of
   MVPN specification [RFC6513].

   When a wild card query is received, the PE will look for the upstream
   PE address in the MVPN Extended query block. The PE will then check
   if it has bound to the wild card SPMSI tunnel from the specified
   upstream PE. If it has, it will populate the Leaf A-D Augmented
   Response Block and PMSI Tunnel Attributes Augmented Response Block
   with the respective values. If the PE has not received any wild card
   SPMSI AD route from the specified upstream PE in the query, it should
   send a response with the error code set to
   NO_WILD_CARD_SPMSI_AD_RCVD. If the PE has received wild card SPMSI
   AD route from the upstream PE, but has not responded with a LEAF-AD
   route, it should send a response with the error code set to
   NO_WILD_CARD_SPMSI_LEAF_AD_SENT.

   For a non-wild-card query, the upstream PE address field in the MVPN
   Extended query block MUST be ignored by the PEs. It MUST follow the
   procedure to find the upstream multicast hop as discussed earlier.

   If the route does not match any MVPN-TIB state, then the PE should
   send a Response to the Querier with the error code set to
   NO_CMCAST_STATE. If the PE cannot locate the upstream PE then it
   should send a response to the Querier with the NO_UPSTREAM_PE error
   code.

   From the selected UMH route, the local PE extracts the ASN of the
   upstream PE (as carried in the Source AS Extended Community of the
   route), and the source-AS field of the mtrace Query is set to that
   AS.

If the local and the upstream PEs are in the same AS, then the RD in
the mtrace Query is set to the RD of the VPN-IP route for the source/
RP.

Section 8 of MVPN specification [RFC6513] mentions two procedures
(Segmented and Non-Segmented) for handling Inter-AS scenarios. If
the local and the upstream PEs are in different ASes, and if
segmented Inter-AS procedure is used, then the local PE finds in its
VRF an Inter-AS I-PMSI A-D route whose Source AS field carries the
ASN of the upstream PE. The RD of the found Inter-AS I-PMSI A-D
route is used as the RD of the mtrace Query. If Inter-AS I-PMSI A-D
route is not found, a response with error code UNKNOWN_INTER_AS is
sent.

To support non-segmented inter-AS tunnels, if the local and the
upstream PEs are in different ASes, the local system finds in its VRF
an Intra-AS I-PMSI A-D route from the upstream PE. The Originating
Router's IP Address field of that route has the same value as the one
carried in the VRF Route Import of the unicast route to the address
carried in the Multicast Source field. The RD of the found Intra-AS
I-PMSI A-D route is used as the RD in the mtrace Query. The Source
AS field in the mtrace Query is set to value of the Originating
Router's IP Address field of the found Intra-AS I-PMSI A-D route.

The PE receiving Mtrace Query will check for any errors. If any
error is detected it will send the error back to the Querier.
Otherwise, it will change the TLV value to be an Mtrace Request, and
it will add a Mtrace2 Standard Response Block. It will also add a
PMSI Tunnel Attributes Augmented Response Block with the attributes
of the PMSI used to receive traffic for the S,G. If a Leaf-AD route
was advertised to the upstream PE for this S,G then the PE will also
include a Leaf-AD Augmented Response Block with the NLRI of the
associated Leaf-AD route.

3.2.1. Ingress PE Procedures

The PE that receives the Request, will check the PMSI attributes of
the sender of request to see if they match the values used to send
traffic for the S,G. If the values do not match, then the PE uses
the appropriate pmsi error code as specified in 'MVPN Error Codes'
section and sends a mtrace Response back to the Querier. Also, if a
Leaf A-D Augmented Response Block is included, the PE will validate
that it has received this Leaf A-D route from the router that sent
the Request. If not, then this PE should change the error code to
BAD_LEAF_AD and send the Response to the Querier. If the PE expects
that a Leaf A-D route is needed for the downstream PE to receive
traffic, but did not receive one in the mtrace Request from the
sending router, then it should use a NO_LEAF_AD_RCVD error code for

the mtrace Response. For a wild card SPMSI query, if the PE didn't
receive LEAF AD route from the downstream PE, it should use
NO_LEAD_AD_RCVD error code.

When the upstream PE receives the Request, it will check for any
errors. If there are errors detected, or if the TTL expired, then
the PE will change the TLV code to be a Mtrace Response and unicast
the response back to the Querier.

The ingress PE will also check it has local vrf connectivity for the
source/RP. If it does not have any connectivity to the source/RP
then it should use the base specification error code NO_ROUTE and
send an mtrace Response. Note that in a Virtual Hub and Spoke
environment, it is possible for a PE to receive a mtrace Request and
need to propagate it to another upstream PE. These procedures are
outlined in the section "Virtual Hub and Spoke". If the PE does not
expect to be receiving mtrace Responses from the mvpn core and have
the route to the source located via another upstream PE, then it can
use the base specification RPF_IF error code.

If the PE that receives the Request is the ingress PE that has local
vrf connectivity for the source, then it will add a Standard Response
Block to the mtrace message. It will not include the additional PMSI
Attributes Response Block. Then it will turn the Request into a
Downstream Request by changing the value of the Type field of the
TLV. It will send the mtrace message on the provider tunnel used to
send the S,G data traffic.

3.3. Downstream Requests

When a router receives Mtrace Downstream Request, it will determine
if it has added any of the Response Blocks for this mtrace message.
If it does not locate its address in the list of Response Blocks,
then it will silently discard this mtrace message. Otherwise, it
will set the 'D' bit in its PMSI Tunnel Attributes Augmented Response
Block to indicate that this message has been received on the PMSI
tunnel.

If this router is the egress PE that provided the initial Response
Block, then it will change the mtrace type to a Reply and sends the
Reply to the Querier (the egress PE and the Querier may be the same
router). Otherwise, this router must send the Downstream PE on the
PMSI that it would normally send traffic for the S,G. Before sending
the Downstream Request, the router must decrement the TTL and check
for TTL expiry. If the TTL has expired, then this router must send
the Response to the Querier with the appropriate code.

3.4. ASBR Behavior

When an ASBR receives a mtrace Request the ASBR finds an Inter-AS
I-PMSI A-D route whose RD and Source AS matches the RD and Source AS
carried in the mtrace Query. If no matching route is found and the
ASBR is using segmented tunnels as described in MVPN specification
[RFC6513], the ASBR sends an UNKNOWN_INTER_AS error code back to the
Querier. If a matching route is found, the ASBR acts as a "first hop
router" and modifies the Query type to DOWNSTREAM_REQUEST. ASBR in
this case MUST validate the PMSI attributes similar to the "first hop
router" and respond if there is any errors. ASBR MUST populate PMSI
Tunnel Attributes Augmented Response Block with the Inter-AS provider
tunnel information before sending the DOWNSTREAM_REQUEST. Note that
the mtrace request does not proceed upstream as it is assumed that
performing a traceroute and exposing IP addresses across AS
boundaries would not be desirable with Segmented Inter-AS Provider
Tunnels.

To support non-segmented inter-AS tunnels as described in [RFC6513],
instead of matching the RD and Source AS carried in the mtrace Query
against the RD and Source AS of an Inter-AS I-PMSI A-D route, the
ASBR should match it against the RD and the Originating Router's IP
Address of the Intra- AS I-PMSI A-D routes. The Next Hop field of
the MP_REACH_NLRI of the found Intra-AS I-PMSI A-D route is used as
the destination for the mtrace Request.

3.5. Virtual Hub and Spoke

When a Virtual-Hub (V-HUB) as described in specification
[I-D.ietf-l3vpn-virtual-hub] receives a mtrace Request the S,G may be
reachable via one of its vrf interfaces. In this case, the V-HUB is
an ingress PE and the procedure are defined in the Section "Ingress
PE Procedures". Otherwise, the C-RP/C-S of the route is reachable
via some other PE. This is the case where the received route was
originated by a Virtual-spoke (V-spoke) that sees the V-HUB as the
"upstream PE" for the given source, but the V-HUB sees another PE as
the "upstream PE" for that source. In this case, the V-HUB should
check the PMSI attributes sent in the mtrace Request against the
Tunnel Attributes of the Provider Tunnel used to send traffic for the
S,G from the upstream PE to the V-Spoke.

The V-HUB sends a mtrace Request to its upstream PE the same way as
it would if it received a mtrace Query. V-HUB MUST add PMSI Tunnel
Attributes Augmented Response Block of its own before sending the
mtrace Request to the upstream PE. It may also add Leaf-AD Augmented
Response Block if a Leaf-AD route was advertised upstream by the
V-HUB. If the RD or Source-AS of the upstream PE is different, the
V-HUB updates the MVPN Extended Query Block accordingly.

3.6. **Inter-Area Provider Tunnels**

3.6.1. **Egress PE**

   The egress PE does the same procedures as specified in
   Section "Mtrace Request" except it sends the Request upstream to the
   IP address determined from the Global Administrator field of the
   Inter-area P2MP Segmented Next-hop Extended Community as described in
   specification [I-D.ietf-mpls-seamless-mcast] . If the egress PE has
   sent a Leaf-AD route then it must send a Leaf-AD Augmented Response
   Block with the NLRI of the Leaf A-D route.

3.6.2. **ABR Behavior**

   ABR MUST find a S-PMSI or I-PMSI route whose NLRI has the same value
   as the Route Key field of the received mtrace Leaf-AD extended Query
   Block. If such a matching route is not found then a Response should
   be sent to the Querier with the NO_LEAF_AD_RCVD. If the ABR has sent
   a Leaf-AD route then it must add a Leaf-AD Augmented Response Block
   with the values of Leaf A-D route NLRI. The upstream node's IP
   address is the IP address determined from the Global Administrator
   field of the Inter-area P2MP Segmented Next-hop Extended Community.

3.7. **Mtrace MVPN Procedure**

   In this section, we will briefly discuss the Mtrace procedure taking
   a working and non-working network topology.

```
  Querier         + Egress PE        + PE/ASBR/ABR      + Ingress PE
  |               |                  |                   |
  |  Query        |                  |                   |
  |+---------->|                     |                   |
  |               |  Request         |                   |
  |               |+------------>     |                   |
  |               |                  |  Request          |
  |               |                  |+---------------->|
  |               |                  |                   |
  |               |                  |                   |
  |               |                  |  Downstream Request|
  |               |                  |<----------------+|
  |  Response     | Downstream Request|                  |
  |<---------- |  <----------------+                     |
  |               |                  |                   |
  |               |                  |                   |
  v               v                  v                   v
```
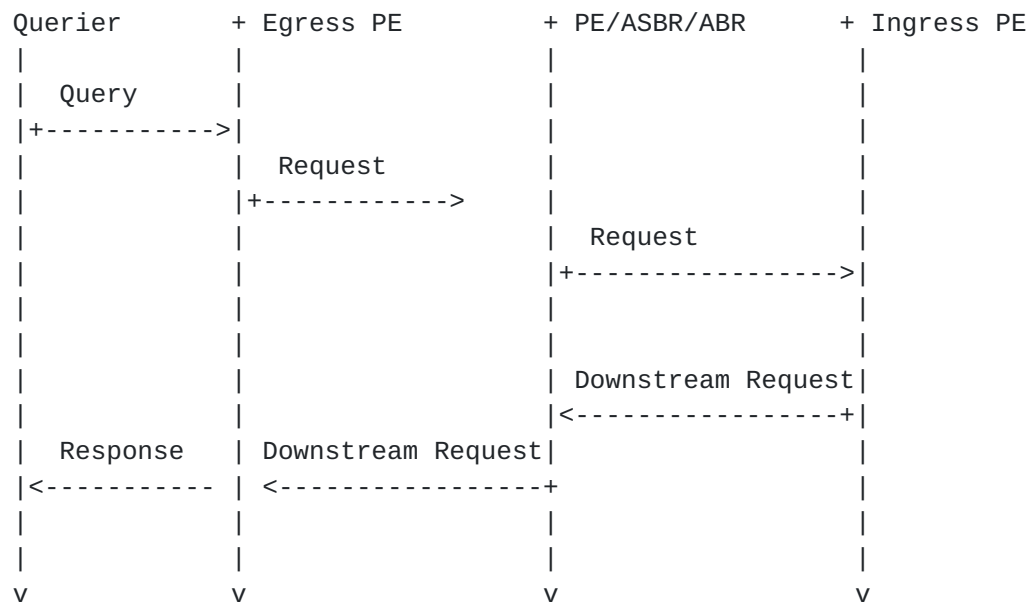
                       Mtrace MVPN Procedure

   The above figure depicts the path of MTRACE in working condition.
   MTRACE request for MVPN can traverse multiple hops when a Virtual HUB
   is present or when segmented P2MP inter-area tunnels are used. If no
   error conditions are detected the downstream request will travel the
   same path as the regular multicast packet for the queried mroute
   would flow. The last hop router/egress router will convert it into a
   Response and send it back to querier

   Let us consider a non-working case where Mtrace is expected to be
   used. Taking Virtual-HUB as an example, assume that there is a data-
   path issue between V-HUB and Egress Spoke. The below steps take
   place to determine the issue between V-HUB and egress Spoke

      1 - Querier sends the Mtrace Query towards LHR (Egress PE-Spoke).

      2 - Egress PE sends Request to V-HUB. V-HUB realises that the
      first hop router is a connected spoke and sends the request to
      Ingress Spoke PE.

      3 - Ingress Spoke PE sends Downstream Request to V-HUB. The same
      is received by V-HUB. V-HUB sets the 'D' bit in its PMSI Tunnel
      Attributes Augmented Response Block.

      4 - V-HUB sends Downstream request to ingress spoke. This is
      never received by the ingress spoke.

5 - The result of first 4 steps is that querier did not receive
the response. This makes the querier fall back to TTL method.

6 - Querier reduces the TTL and the result will show that the hop
from V-HUB to ingress spoke is missing thereby pointing the issue
at the right place.

4. Error Detection

All routers will check for normal multicast errors as defined in the
Mtracev2 specification. In addition, they will check for errors
specific to MVPNs and this specification.

All receiving routers will check the state of the Provider Tunnel
used for forwarding traffic for the given S,G. The ability and
manner to check if the Provider Tunnel is down depends on the
Provider Tunnel type. If the Provider Tunnel is known to be down the
PE will respond with a PTUNNEL_DOWN error.

In some situations the router needs to send a Leaf AD route to the
upstream PE. If the upstream expects a Leaf AD route, but did not
receive one from the downstream PE, then the NO_LEAF_AD_RCVD error
will be sent.

The receiving router will check the values of the PMSI Tunnel
attributes to see if they match the expected values for the PMSI. If
an Inclusive-PMSI is used, then the router will verify that the
values match those in the I-PMSI A-D route. If a Selective PMSI is
used, then the Tunnel Attributes will be matched against the S-PMSI
or Leaf A-D Route, depending on the Tunnel Type. If the values do
not match, then a error code of the corresponding PMSI mismatch will
be sent.

If a router receives a MVPN traceroute, but does not have the proper
MVPN configuration, then it will respond with a UNEXPECTED_MVPN error

4.1. MVPN Error Codes

```
   Value   Name                                     Description
   -----   --------------
   ---------------------------------------
   0x11   PTUNNEL_DOWN                      The provide tunnel for this S,G
is down.

   0x12   NO_LEAF_AD_RCVD                   The S-PMSI has not been joined by
                                            downstream neighbor

   0x13   BAD_LEAF_AD                       The Leaf A-D route does not match
                                            the expected values

   0x14   BAD_RD                            The RD is known to not exist on
this PE

   0x15   UNEXPECTED_MVPN                   The MVPN traceroute message is
unexpected

   0x16   BAD_PMSI_ATTR_FLAG                Error matching the PMSI attribute
flag

   0x17   BAD_PMSI_ATTR_TYPE                Error matching the PMSI attribute
type

   0x18   BAD_PMSI_ATTR_LABEL               Error matching the PMSI attribute
label

   0x19   BAD_PMSI_ATTR_ID                  Error matching the PMSI attribute
tunnel

                                            identifier

   0x1a   UNKNOWN_INTER_AS                  Could not locate the Inter-AS
provider

                                            tunnel segment.

   0x1b   NO_UPSTREAM_PE                    No valid upstream PE or route

   0x1c   NO_CMCAST_STATE                   No C-Mcast route for the
requested query

   0x1d   NO_WILD_CARD_SPMSI_AD_RCVD        No Wild Card SPMSI SPMSI AD is
received from the upstream PE
   0x1e   NO_WILD_CARD_SPMSI_LEAD_AD_SENT   PE did not send LEAF-AD route for
the wild card SPMSI
```
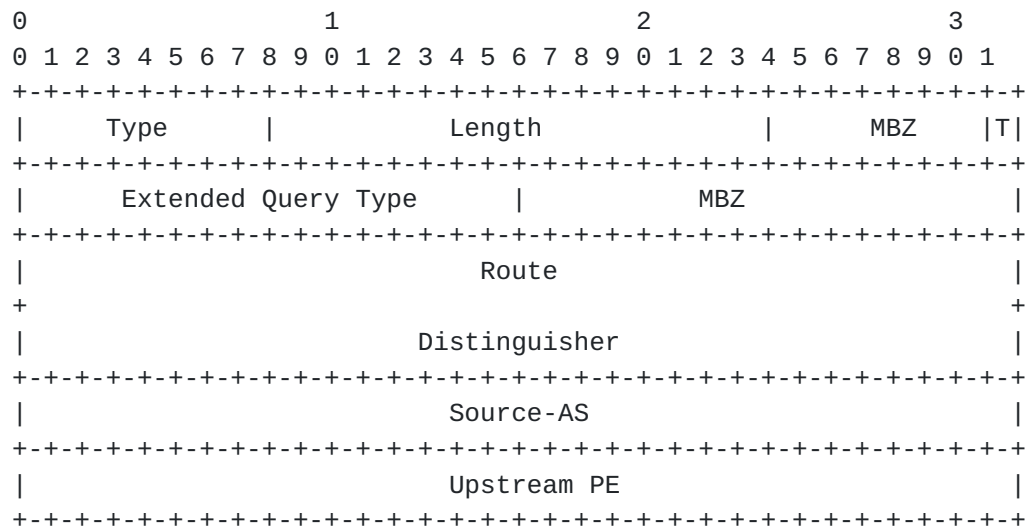
5. Mtracev2 Extensions

5.1. New Mtracev2 TLV Type

A new Mtracev2 TLV type will be created for the Mtrace2 Downstream
Request.

5.2. MVPN Extended Query Block

```
 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           |    MBZ    |T|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Extended Query Type       |            MBZ            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            Route                          |
+                                                           +
|                       Distinguisher                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Source-AS                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Upstream PE                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

MVPN Extended Query Block

Type: Mtrace2 Extended Query Block Type

Length: Length of the MVPN Extended Query Block

MBZ: Sent with all 0's, ignored on receipt

T bit: This bit should be 0

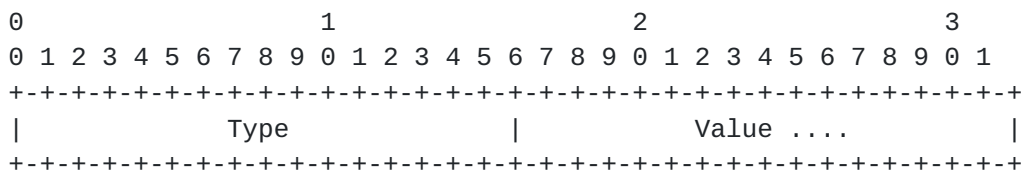Extended Query Type: New type defined

MBZ: Sent with all 0's, ignored on receipt

Route Distinguisher: The RD of the S,G that should be traced

Source-AS: The Autonomous System Number (ASN) of the Source

Upstream PE: IP Address of the Upstream PE

5.3. Leaf A-D Augmented Response Block

```
 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            |          Value ....           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Leaf A-D Augmented Response Block

MBZ: Sent with all 0's, ignored on receipt

Type: New type defined

Value: The NLRI value of the associated Leaf A-D route

5.4. PMSI Tunnel Attributes Augmented Response Block

```
 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             |D|    MBZ     | Value..       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

           PMSI Tunnel Attributes Augmented Response Block

MBZ: Sent with all 0's, ignored on receipt

Type: New type defined

D: 'D' bit indicating that Downstream Request is received on PMSI

Value: The PMSI Tunnel Attribute as defined in RFC 6514

6. Mtrace2 Standard Response Block considerations

The PEs in the MVPN Mtrace add the Standard Response Block as defined
in Mtrace2 [I-D.ietf-mboned-mtrace-v2]. For a PE, the incoming or
outgoing interface can be a Tunnel. The First Hop Router (FHR) PE
which is connected to the source SHOULD populate the incoming
interface address with the respective interface connected to the CE.
The outgoing interface address MAY be populated with 0 in this case.
Other routers in the mtrace path MAY populate incoming and outgoing
interface address fields as 0. 'Multicast Rtg Protocol' field MUST
be populated with 0s by the Last Hop Router (LHR). First Hop Router
(FHR) can populate this field with respective multicast routing
protocol used towards its upstream CE. All the remaining fields of
the Standard Response Block are populated as defined by the Mtrace2
[I-D.ietf-mboned-mtrace-v2] specification.

7. IANA Considerations

New TLV Type for MTRACE_MVPN_QUERY, MTRACE_MVPN_REQUEST,
MTRACE_MVPN_DOWNSTREAM_REQUEST, MTRACE_MVPN_RESPONSE

8. Security Considerations

   There are no security considerations for this design other than what
   is already in the mtracev2 specification.

9. Acknowledgments

   The authors would like to thank Yakov Rekhter and Marco Rodrigues for
   their valuable review and feedback.

10. Normative References

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