Segment Routing in MPLS-TP Inter-domain Use Cases
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Abstract

   This document discusses SR-MPLS-TP inter-domain scenarios and use
   cases, and also SR-MPLS-TP inter-working with MPLS-TP network
   requirement and use cases.

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1. Introduction

   Segment Routing (SR) leverages the source routing paradigm. A node
   steers a packet through an SR Policy instantiated as an ordered list
   of instructions called "segments". A segment can represent any
   instruction, topological or service based. A segment can have a
   semantic local to an SR node or global within an SR domain. SR
   supports per-flow explicit routing while maintaining per-flow state
   only at the ingress nodes to the SR domain. Segment Routing can be
   instantiated on MPLS data plane or IPv6 data plane. The former is
   called SR-MPLS [I-D.ietf-spring-segment-routing-mpls] , the latter is
   called SRv6 [I-D.ietf-6man-segment-routing-header]. SR-MPLS
   leverages the MPLS label stack to construct SR path, and SRv6 uses
   the Segment Routing Header to construct SR path.

   [I-D.cheng-spring-mpls-path-segment] provides a path segment to
   support bidirectional path correlation in an AS domain. A Path
   Segment is defined to unique identify an SR path in a specific
   context. This document proposes to discuss SR-MPLS-TP inter-domain
   scenarios and use cases, and SR-MPLS-TP inter-working with MPLS-TP
   network requirement and use case.

2. Conventions used in this document

2.1. Terminology

A->B SID list: The SID List from SR node A to SR node B.

AS: Autonomous Systems.

BSID: Binding SID.

e-Path: End-to-End path segment.

MPLS-TP: MPLS transport profile.

s-Path: Sub-path path segment.

SR: Segment routing.

SR-MPLS: Segment routing with MPLS data plane.

SR-MPLS-TP: Segment routing transport Profile with MPLS data plane.

2.2. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

3. SR-MPLS-TP Inter-domain

There are two SR-MPLS-TP inter-domain models defined in this document: stitching inter-domain model and nesting inter-domain model. The stitching inter-domain model is that the end-to-end SR path segment are split into multiple domain path segments. Each SR-MPLS-TP domain has its domain path segment. The domain path segment is valid in its own domain, and the border nodes maintain the forwarding entries of its domain path segment mapping to other domain path segment. There are two scenarios for stitching SR-MPLS-TP inter-domain: border node inter-domain(section 3.1.1) and border link inter-domain scenarios(section 3.1.2).

The nesting inter-domain model is that an e-Path segment is used to indicate the end-to-end bidirectional path tunnel, and a s-Path is used to indicate the domain bidirectional path tunnel. The e-path segment is encapsulated in the ingress nodes, and decapsulated in the egress nodes. The transmit nodes, even the border nodes of domains, do not aware of the e-path segment(section 3.2 for details). The

s-Path are encapsulated and decapsualted in the border nodes of its
domain.

3.1. SR-MPLS-TP Stitching Inter-domain

3.1.1. Border Node Inter-domain Scenario

The following figure shows the border node inter-domain scenario. SR
node X and SR node Y are the border nodes of two different Autonomous
Systems. The Path labels (Path1, Path2, Path3, Path1',Path2' and
Path3') [I-D.cheng-spring-mpls-path-segment] are used for inter-
domain bidirectional tunnel indication. Path 1, Path 2 and Path3 are
used for the forwarding path from A to Z, and Path1', Path2' and
Path3' are used for the reverse path (from Z to A). The border nodes
should install the following MPLS data entries for Path labels:

    incoming label: Path Label
       outgoing label: the SID list of the next AS domain + next Path label

Taking figure 1 as the example, the border node X installs the MPLS
data entries:

        incoming label: Path1
           outgoing label: X-Y SID list + Path 2

The ingress SR node A encapsulates the data packet with Path1 label
and A-X SID list. The data packet forwards to SR node X according to
the A-X SID list. Node X encapsulates the Path2 label and X-Y SID
list based on the above forwarding entry. The data packet forwards
to node Y and even to destination SR node Z based on the same
forwarding procedure. The egress node Z pops the path label and
reverses back the data packet to the node Y. Node Y encapsulates the
Path3' label and Y-X SID list and forwards the packet to node X, and
X sends back to the ingress node based on the same forwarding
procedure.

```
     ..................   ................   ...................
         .               .   .             .   .                 .
         .               .   .             .   .                 .
  +-----+            +-----+           +-----+          +-----+
  | A  |            | X  |           | Y  |          | Z  |
  +-----+            +-----+           +-----+          +-----+
         .               .   .             .   .                 .
         .      AS 1     .   .     AS2     .   .     AS3         .
         ..................   ................   ...................


     Node A                Node X                Node Y
+-------------+      +-------------+      +-------------+
|A-X SID list |      |X-Y SID list |      |Y-Z SID list |          Node Z
+-------------+      +-------------+      +-------------+    +--------------+
|    Path1    |----\|    Path2    |----\|    Path3    |---\|   Payload    |
+-------------+----/+-------------+----/+-------------+---/+--------------+
|  Payload    |      |  Payload    |      |  Payload    |
+-------------+      +-------------+      +-------------+
```
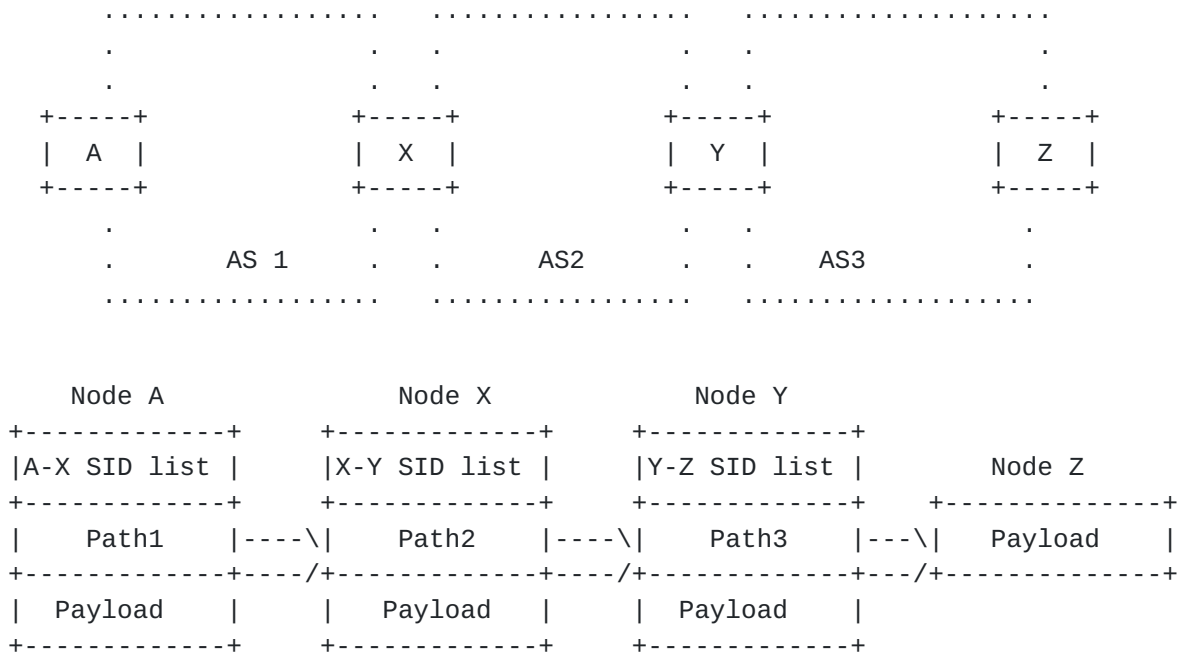
             Figure 1: Stitching Border Node Inter-Domain Scenario

3.1.2. Border Link Inter-domain Scenario

   Figure 2 is the border link inter-domain scenario. All the SR nodes
   belong to one AS in this scenario. The border nodes of different
   Autonomous Systems are connected with direct physical or logical
   links. The Path labels are not only assigned to the Autonomous
   System, they are assigned to the links of the two ASes, for example,
   the Path 2 (Path 2') and Path 4(Path 4') are assigned to the links
   between AS1 and AS2, and between AS2 and AS3 respectively.

   Ingress SR node A encapsulates the data packet with Path1 and A-B SID
   list. The data packet forwards to SR node B according to the A-B SID
   list. Node B encapsulates Path2 and the inter-domain link
   label(label B-C) according to the forwarding entry, and forwards the
   packet to Node C. SR node C forwards the packet to node X, then to
   Y. The data packet forwards the destination SR node Z according to
   the same forwarding procedure.

   The border nodes should install the following MPLS data entries for
   Path labels:

      incoming label: Path Label
         outgoing label: the SID list of the next AS domain + next Path label

   If the border node belongs to the outgoing AS domain for the data
   packet, the SID-List is the label assigned to the link between two

   border nodes of different AS domains for the border link inter-domain
   scenario. The procedure of assigning and processing that link label
   is out of scope.


```
      ....................    ....................    ....................
      .                  .    .                  .    .                  .
      .                  .    .                  .    .                  .
      .+---+      +---+  .    . +---+      +---+  .    .+---+      +----+ .
      .| A |-------| B |------ | C |------| X |-------| Y |------| Z  | .
      .+---+      +---+  .    . +---+      +---+  .    .+---+      +----+ .
      .                  .    .                  .    .                  .
      .     AS 1         .    .       AS2        .    .       AS3        .
      ....................    ....................    ....................


          Node A                 Node B                 Node C
      +-------------+        +-------------+        +-------------+
      |A-B SID list |        | Label B->C  |        |C->X SID list|
      +-------------+        +-------------+        +-------------+
      |    Path1    |----\|      Path2    |----\|      Path3    |----\
      +-------------+----/+-------------+----/+-------------+----/
      |  Payload    |        |  Payload    |        | Payload     |
      +-------------+        +-------------+        +-------------+



          Node X                 Node Y
      +-------------+        +-------------+
      | Label X->Y  |        |Y->Z SID list|              Node Z
      +-------------+        +-------------+        +--------------+
      |    Path4    |----\|      Path5    |----\|   Payload    |
      +-------------+----/+-------------+----/+--------------+
      |  Payload    |        |  Payload    |
      +-------------+        +-------------+
```
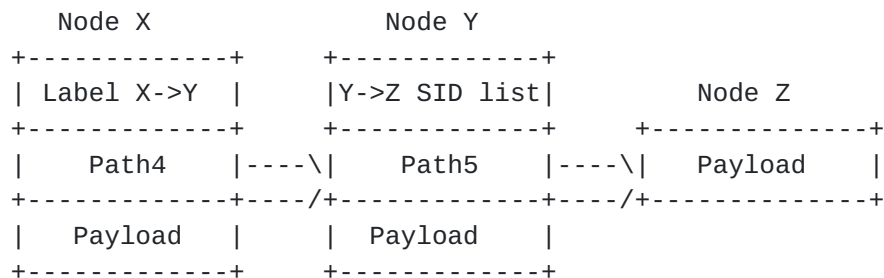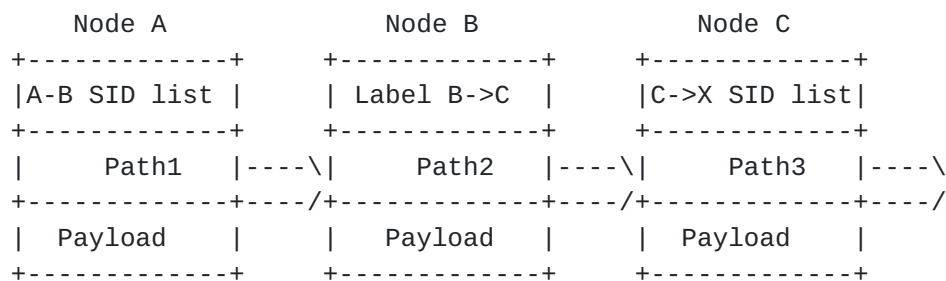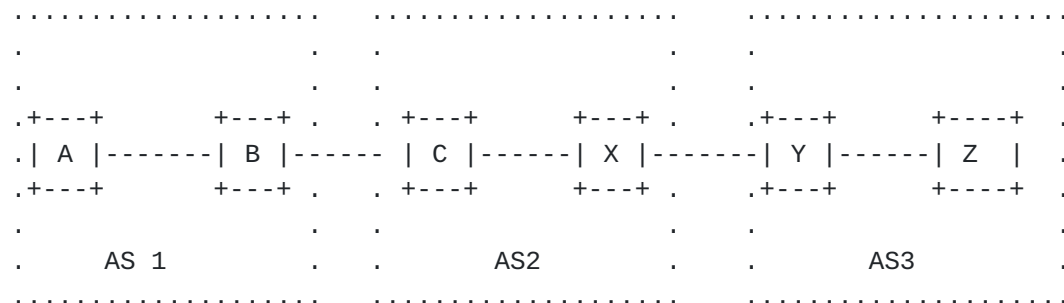
          Figure 2: Stitching Border Link Inter-Domain Scenario

3.2. SR-MPLS-TP Nesting Inter-domain

   Figure 3 shows the SR-MPLS-TP nesting inter-domain scenario. The
   e-Path(A->Z) is used to indicate the end-to-end bidirectional tunnel.
   The s-Path is used to indicate its domain sub-path bidirectional
   tunnel. The e-Path, s-Path and SR list are encapsulated in the
   ingress node. In order to reduce the label stacks, the binding
   SID([RFC8402]) is recommended to be used to replace the SR list of
   each domain. As the figure 3 shows, B-SID(X,Y) is used to replace
   the X-Y SID list. Ingress node A pushes e-Path(A->Z), B-SID(Y->Z),

B-SID(X-Y), s-Path(A->X) and A-X SID list in turn. When the packet
is received in node X, the s-Path(A-X) and X-Y SID list are popped, a
new s-Path(X->Y) is pushed, and BSID(X->Y) is replaced by X-Y SID
list to indicate the packet being forwarded from node X to node Y.

The e-Path can be global unique or local label. If the e-Path is
global unique, it occupies the SRGB block of each domain. While if
the e-Path is a local label, it is required the controller(PCE) or
super controller(or hierarchical PCE) to assign the label to ensure
that ingress(A) and egress node(Z) can recognize it and there is no
SID confliction in the ingress and egress domains.

```
      .................    ...............    ...................
      .              .     .      .     .     .               .
      .              .     .      .     .     .               .
    +-----+          +-----+      +-----+      +-----+
    |  A  |          |  X  |      |  Y  |      |  Z  |
    +-----+          +-----+      +-----+      +-----+
      .              .     .      .     .     .               .
      .     AS 1     .     .    AS2   .     .    AS3        .
      .................    ...............    ...................

     Node A
+-------------+
|A-X SID list |          Node X
+-------------+       +-------------+
|s-Path(A->X) |       |X-Y SID list |          Node Y
+-------------+       +-------------+       +-------------+
|B-SID (X->Y) |       |s-Path(X->Y) |       |X-Y SID list |
+-------------+       +-------------+       +-------------+
|B-SID( Y->Z) |       |B-SID( Y->Z) |       |s-Path(Y->Z) |          Node Z
+-------------+       +-------------+       +-------------+       +-------------+
|e-Path(A->Z) |       |e-Path(A->Z) |       |e-Path(A->Z) |       |e-Path(A->Z) |
+-------------+       +-------------+       +-------------+       +-------------+
|  Payload    |       |   Payload   |       |   Payload   |       |  Payload    |
+-------------+       +-------------+       +-------------+       +-------------+
```
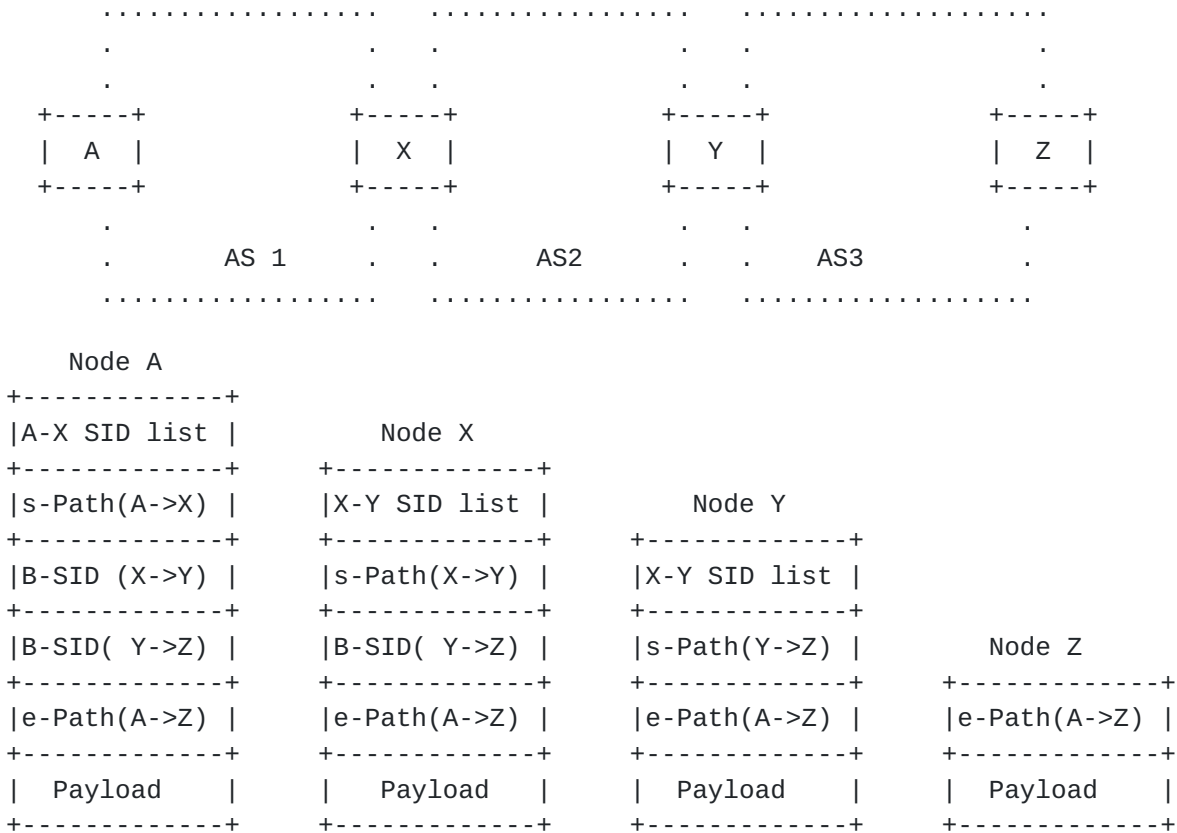
Figure 3: Nesting Inter-Domain Scenario

[4]. SR-MPLS-TP Inter-working with MPLS-TP

It is a common requirement that SR-MPLS-TP needs to inter-work with
MPLS-TP when SR is incrementally deployed in the MPLS-TP domain.

Figure 4 shows the stitching SR-MPLS-TP inter-working with MPLS-TP,
the left part is SR-MPLS-TP network, and the right part is MPLS-TP

network. The Path label is used for the bidirectional tunnel
indication in SR-MPLS-TP network. The Border nodes of SR-MPLS-TP
network should map the Path label to the corresponding MPLS-TP label
for bidirectional tunnel indication in MPLS-TP network.

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    ................................    ...................................
.                                  .    .                                 .
.+---+        +---+       +---+ .    . +---+       +---+      +----+  .
.| A |-------| B |------ | C |-.-----.-| U |-------| V |------| W  |  .
.+-+-+        +-+-+       +---+ .    . +---+       +-+-+      +-+--+  .
. |            |                .    .               |          |     .
. |            |                .    .               |          |     .
.+-+-+        +-+-+       +---+ .    . +---+       +-+-+      +-+--+  .
.| D |-------| E |------ | F |-.-----.-| X |-------| Y |------| Z  |  .
.+---+        +---+       +---+ .    . +---+       +---+      +----+  .
.                                  .    .                                 .
.    SR-MPLS-TP  domain         .    .         MPLS-TP domain        .
................................    ...................................

|<----------SID List----------->|<--------------MPLS-TP label------->|
|<--------Path label----------->|
|<-------------------------VPN Service------------------------------>|
```
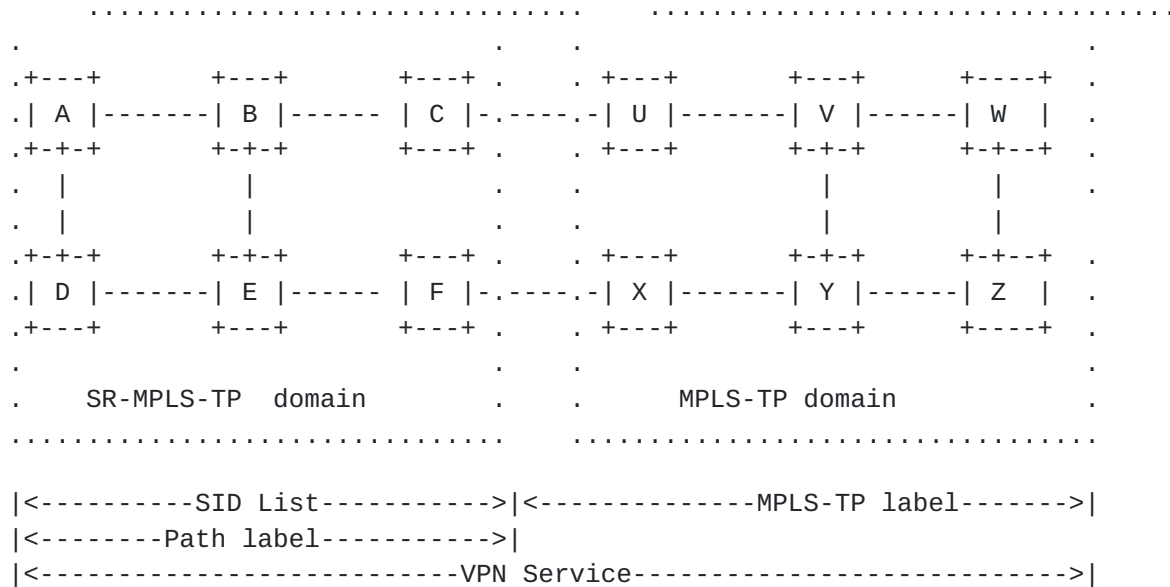
Figure 4: Stitching SR-MPLS-TP inter-working with MPLS-TP

Figure 5 is the nesting SR-MPLS-TP inter-working with MPLS-TP
scenario. The difference with stitching SR-MPLS-TP inter-working
with MPLS-TP is that the Path label is end-to-end encapsulation in
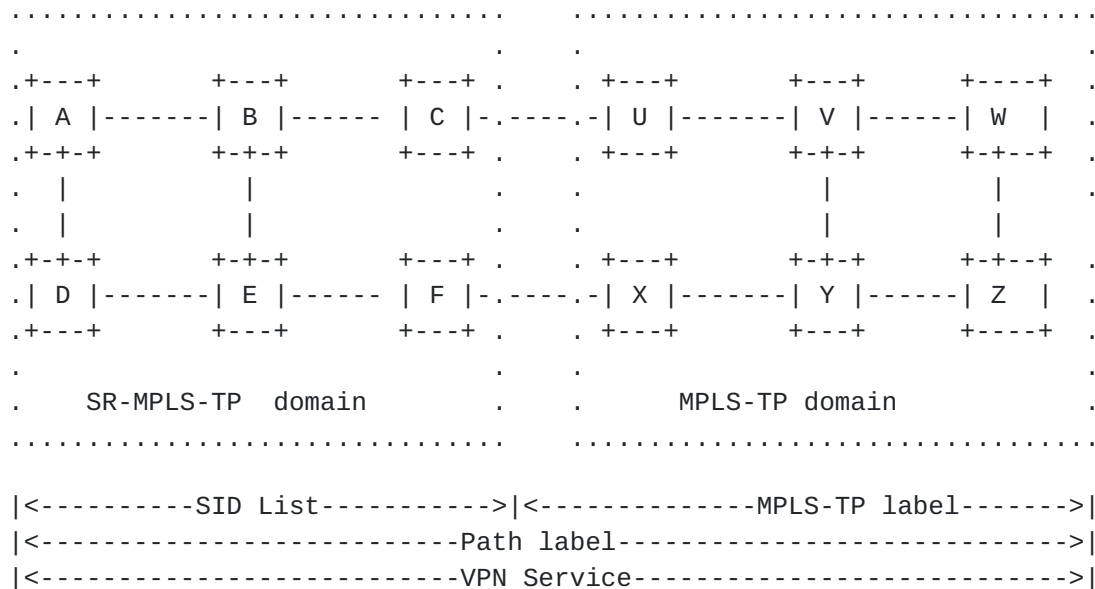the packet from SR-MPLS-TP domain to MPLS-TP domain.

```
 ...............................     ...................................
 .                              .   .                                   .
 .+---+      +---+      +---+ .   . +---+      +---+      +----+  .
 .| A |-------| B |------ | C |-.-----.-| U |-------| V |------| W |  .
 .+-+-+      +-+-+      +---+ .   . +---+      +-+-+      +-+--+  .
 . |          |              .   .                |          |     .
 . |          |              .   .                |          |     .
 .+-+-+      +-+-+      +---+ .   . +---+      +-+-+      +-+--+  .
 .| D |-------| E |------ | F |-.-----.-| X |-------| Y |------| Z |  .
 .+---+      +---+      +---+ .   . +---+      +---+      +----+  .
 .                              .   .                                   .
 .    SR-MPLS-TP  domain        .   .      MPLS-TP domain              .
 ...............................     ...................................

 |<----------SID List----------->|<--------------MPLS-TP label------->|
 |<---------------------------Path label----------------------------->|
 |<--------------------------VPN Service------------------------------>|
```

           Figure 5: nesting SR-MPLS-TP inter-working with MPLS-TP

   The requirement of the SR-MPLS-TP inter-working with MPLS-TP is as
   following:

   o It is required to establish the end-to-end VPN service through SR-
      MPLS-TP domain and MPLS-TP domain;

   o The Path Label is required to carried through SR-MPLS-TP and MPLS-
      TP domain in nesting SR-MPLS-TP inter-working with MPLS-TP model.

   o The border nodes of MPLS-TP network could understand and process
      the path segment from SR-MPLS-TP network.

   o The border nodes in MPLS-TP could understand and process MPLS SID
      sent from MPLS-SR-TP domain

   o The border nodes in SR-MPLS-TP network could understand and
      process the MPLS-TP labels sent from MPLS-TP domain;

5. Security Considerations

6. Acknowledgements

7. IANA Considerations

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