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Unified Identifier in IPv6 Segment Routing Networks
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Abstract

Segment Routing architecture leverages the paradigm of source routing. It can be realized in a network data plane by prepending the packet with a list of instructions, a.k.a. segments. A segment can be encoded as a Multi-Protocol Label Switching (MPLS) label, IPv4 address, or IPv6 address. Segment Routing can be applied in the MPLS data plane by encoding segments in an MPLS label stack. It also can be applied to the IPv6 data plane by encoding a list of segment identifiers in IPv6 Segment Routing Extension Header (SRH). In this document is described the use of unified segment identifiers in use cases where interworking between SR-MPLS and SRv6 is required.

Status of This Memo

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1. Introduction

Many functions related to Operation, Administration and Maintenance (OAM) require identification of the SR tunnel ingress and the path, constructed by segments, between the ingress and the egress SR nodes. Combination of IPv6 encapsulation [RFC8200] and the Source Routing Extension Header (SRH) [I-D.ietf-6man-segment-routing-header], referred to as SRv6, comply with these requirements while it is challenging when applying SR in MPLS networks [I-D.ietf-spring-segment-routing-mpls], also referred to as SR-MPLS.

On the other hand, the size of the IPv6 segment identifier (SID) presents a scaling challenge to use topological instructions that define a strict explicitly routed path in combination with service-based instructions. At the same time, that is where the SR-MPLS approach provides better results due to smaller SID length.

SR-MPLS currently, more often than SRv6, is used in metro networks. With the gradual deployment of SRv6 in the core networks, it becomes necessary to support interworking between SR-MPLS and SRv6. Operationally it would be more efficient and straightforward if SRv6 can use the same size SIDs as in SR-MPLS. The SRH can be extended to use the same as in SR-MPLS SID length to support the unified segment identifier (U-SID) [I-D.mirsky-6man-unified-id-sr]. As a result of using this approach, U-SIDs can be used end-to-end across a tunnel that spans over SR-MPLS and SRv6 domains.

In this document is described the use of unified segment identifiers, encoded as MPLS label and/or 32 bits-long address, in use cases when interworking between SR-MPLS and SRv6 networks is required.

1.1. Conventions used in this document

1.1.1. Terminology

SR: Segment Routing

SRH: Segment Routing Extension Header

MPLS: Multiprotocol Label Switching

SR-MPLS: Segment Routing using MPLS data plane

SID: Segment Identifier

IGP: Interior Gateway Protocol

OAM: Operation, Administration and Maintenance

SRv6: Segment Routing in IPv6

U-SID: Unified Segment Identifier

1.1.2. 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.

2. Requirements for Using SRv6 in Backhaul

2G/3G/4G backhaul networks widely deploy MPLS to connect wireless services. Many operators are already deploying 5G networks. To optimize the operation of the network, many operators intent to adopt the segment routing. Currently, given maturity of SR-MPLS, it has been deployed on a large scale. Meanwhile the requirements of 5G super-large-scale number of connections accelerate the deployment of IPv6 networks. Thus, logically, operators consider SRv6 solution to fulfill the 5G backhaul requirement. But the backhaul network could not deploy SRv6 in one day, especially if it has already been using MPLS and SR-MPLS. It might be reasonable to upgrade from MPLS to SR-MPLS and then to SRv6. There are several essential operational requirements for the deployment of SRv6 in 5G backhaul network:

1. Ensure the ability to transform the existing SR-MPLS backhaul network into an SRv6 5G backhaul network incrementally.

2. Support interworking between SRv6 and SR-MPLS domains in the network.

3. Support SRv6 header compressing.

4. Support super-large-scale networking and address planning

3. Using SRv6 U-SID in Backhaul

U-SID provides a solution that complies to the 5G backhaul requirements.

3.1. Smoothly Upgrading to SRv6 from SR-MPLS

SR-MPLS uses a segment encoded as a label in an MPLS label stack to simplify the backhaul network. It leverages the advantages of both source-routing and MPLS. Existing backhaul networks that use MPLS can be first updated to use SR-MPLS. SRv6 uses the segment encoded as an identifier in IPv6 SRH. The SR-MPLS and SRv6 protocol stacks are illustrated in Figure 1.

```
   +------------------+        +------------------+
   |     Ethernet     |        |     Ethernet     |
   +------------------+        +------------------+
   |                  |        |                  |
   |     SR-MPLS      |        |       SRv6       |
   |                  |        |                  |
   +------------------+        +------------------+
   |     Payload      |        |      Payload     |
   +------------------+        +------------------+
```

Figure 1: SR-MPLS and SRv6 Protocol Stacks

A segment identifier in SR-MPLS occupies 32 bits, and in SRv6 - 128 bits. As the backhaul infrastructure being upgraded to IPv6, operators are looking for technology that would reuse SR-MPLS by re-mapping the label table. But the namespace in SR-MPLS is limited and couldn't build the new segment identifiers to the global network. Using U-SID with SRv6 allows the reuse of the 32-bit SIDs, which are the same as in SR-MPLS. Thus, U-SID with SRv6 can be reused in backhaul to minimize the impact on existing SR-MPLS services and support smooth rollout of SRv6. The only additional task is to assign U-SIDs to the SRv6 domain. The controller could create an end-to-end SR tunnel using 32bit-long segments identifiers to stitch the SR-MPLS and SRv6 domains.

3.2. Interworking Between SRv6 and SR-MPLS

For a 5G backhaul network, the operators want to try their best to reuse the existing transport network. Consequently, they must consider the SRv6 interworking with SR-MPLS while deploying SRv6. Using U-SID offers a practical approach to native interworking between SR-MPLS and SRv6 domains because an operator in both domains can use segment identifiers of the same format, U-SID.

Using U-SID interworking between SRv6 and SR-MPLS brings some significant advantages:

1. An end-to-end LSP can be created across the access/aggregation network with SR-MPLS and core network with SRv6.

2. An end-to-end OAM and protection mechanism can be supported reusing SR-MPLS

The SR-MPLS and SRv6 interworking is illustrated in Figure 2. An end-to-end SR tunnel from A to F crosses the SR-MPLS and SRv6 domains. Using U-SID end-to-end LSP can reuse SR-MPLS forwarding, and support end-to-end OAM and protection.

```
             +-----+       +-----+       +-----+       +-----+
       LSP-->|  A  +-------+  B  +-------+  E  +-------+  F  |-->
             +-----+       +--+--+       +--+--+       +--+--+
                |   SR-MPLS   |             |    SRv6     |
                | Access/Agg  |             |    Core     |
             +-----+       +--+--+       +--+--+       +--+--+
             |  C  |-------|  D  +-------+  G  +-------+  H  |
             +-----+       +-----+       +-----+       +-----+
```

Figure 2: SR-MPLS and SRv6 Interworking

3.3. Compressing SRv6 Header Effectively

While deploying SRv6 in the backhaul network, the SRv6 header overhead must be considered. Typically there a maximum of ten hops for an end-to-end transport path. The header overhead is 1280 bits (10*128 bit SRH) using SRH with the 128-bit SID without OAM and protection. It will be reduced to 320 bits (3*128 bit SRH) using U-SID SRv6 with 32-bit SID. So the compressing rate is more than 70% (from at least 10*128 bit SRH to 3*128 bit SRH).

3.4. Support a Super-large-scale Networking and Flexibility in Assigning Addresses

The scale of the backhaul network is up to 10K nodes. A network of such size needs to support to address up to 10K nodes. U-SID SRv6 can support the 2^20 labels as the same with MPLS, and it’s enough for a super-large-scale backhaul networking. Since IPv6 solves the problem of a shortage of IPv4 addresses, it should not be using a shorter IPv6 address, i.e., a shorter prefix plus a shorter offset. That will violate the original IPv6 design. On the other hand, using SRv6 should not require the assignment of special addresses for the operator’s network. U-SID can preserve the full 128-bit addresses by re-mapping the table. To use U-SID in SRv6 doesn’t require the IPv6 address and SRv6 segments planning, such as the address prefix allocation. The operator would reuse the current address assignment and planning, thus minimizing the impact on the backhaul network.

4. Operations with Unified Segment Identifier

When the SRH is used to include 20-bits or 32-bits U-SIDs the ingress and transit nodes of an SR tunnel act as described in Section 5.1 and Section 5.2 of [I-D.ietf-6man-segment-routing-header] respectively.

5. IANA Considerations

This document has no requests to IANA. This section can be removed before the publication.

6. Security Considerations

This specification inherits all security considerations of [RFC8402] and [I-D.ietf-6man-segment-routing-header].

7. Acknowledgements

TBD

8. Normative References

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