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W. Cheng
China Mobile
C. Xie
China Telecom
R. Pang
China Unicom
Z. Li
Huawei Technologies
R. Chen
ZTE Corporation
L. Zu
Unionpay
X. Duan
China Mobile
G. Mirsky
ZTE Corporation
D. Dukes
Cisco Systems, Inc
S. Zadok
Broadcom

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Shorter SRv6 SID Requirements
draft-cheng-spring-shorter-srv6-sid-requirement-02

Abstract

This document describes a list of requirements for the use of a shortened identifier in a segment routing network with the IPv6 data plane.

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1. Introduction

Segment routing (SR) [RFC8402] is a source routing paradigm that explicitly indicates the forwarding path for packets at the ingress node by inserting an ordered list of instructions, called segments.

A segment can be encoded as a Multi-Protocol Label Switching (MPLS) label, IPv4 address, or IPv6 address. Segment Routing can be deployed on the MPLS data plane by encoding 32-bits SIDs in MPLS label stack [RFC8660]. It also can be deployed on the IPv6 data plane by encoding a list of 128-bits SRv6 SIDs in IPv6 Segment Routing Extension Header (SRH)[I-D.ietf-6man-segment-routing-header].

The SRv6 Network Programming [I-D.ietf-spring-srv6-network-programming] specifies the base set of SRv6 behaviors that enables the creation of interoperable overlays with underlay optimization.

However, the size of the SRv6 SID presents a scalabilities challenge to use topological instructions that define a strict explicitly routed path in combination with service-based instructions. At the same time, the size of the SRH/SID may be a challenge for some data plane processors and traffic overhead. Meanwhile, 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 and upgrading to SRv6 from SR-MPLS. It requires some solutions to resolve these problems.

2. Conventions used in this document

2.1. Terminology

SR: Segment Routing

SRH: Segment Routing Extension Header

MPLS: Multiprotocol Label Switching

SR-MPLS: Segment Routing over MPLS data plane

SID: Segment Identifier

SRv6: Segment Routing over IPv6

2.2. Keywords

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. Typical Application Scenarios

At present, only typical application scenarios are discussed, and other scenarios will be considered in the next version.

In the scenario of the mobile backhaul network shown in Figure 1, the eNodeB communicates with RC (Radio Controller). SRv6 path can be set up between the ASGs (Access Site Gateway) and the RSG (RC Site Gateway) to bear mobile services. For a strict SRv6 TE path in this

scenarios, the typical number of the SIDs in the SRH is about 5 to 8 and the maximum is 10.

In the scenario of the mobile backhaul network, there are two different domains. The domain between the ASGs and the AGGs (Aggregation Gateway) is the access domain. And the domain between the AGGs and the RSGs is the aggregation domain. The locators of the SRv6 SIDs in each domain can share the common prefix. But the locators of different domains may be different, meaning they cannot share the common prefix.

```
eNodB2---ASG2-------AGG1------P1------RSG1------RC1
          |          |                 |
          |          |                 |
eNodB1---ASG1        |                 |
          |          |                 |
          |          |                 |
eNodB1---ASG3-------AGG2------P2------RC2-------RC2
```

Figure 1. Mobile Backhaul Network

In the scenario of multiple network domains shown in Figure 2, the typical case is that Domain 1 and Domain 3 can be the mobile backhaul networks and the Domain 2 can be the IP backbone network. An SRv6 path can be set up from the node in Domain 1 and end up at the node in Domain 3 for bearing mobile services, which will travel multiple network domains. In this case, the typical number of the SIDs in the SRH for the E2E SRv6 path may be up to 15, that is, for each network domain, the typical number of the SIDs in SRH for each network domain is 5. Though Binding SIDs [RFC8402] can be used for shortening the SIDs List.

In the scenario of multiple network domains, the locators of the SRv6 SIDs in each network domain can share the common prefix. But the locators of different network domains may be different, meaning they does not share the common prefix.

```
     A1--A3--ASBR11--ASBR21---P3--ASBR23--ASBR31--B3--B1
     |         |       |             |       |         |
     |         |       |             |       |         |
     | Domain1 |       |   Domain2   |       | Domain3 |
     |         |       |             |       |         |
     |         |       |             |       |         |
     A2--A4--ASBR12--ASBR22--P4---ASBR24--ASBR32--B4--B2
```

Figure 2. Multiple Network Domains

4. Analysis of SRH Overhead

There are three major concerns about SRH overhead:

1. Path MTU

Since an SRv6 SID is a 128-bits value, when many SRv6 SIDs are carried within an SRH, the large size overhead introduced by the SRH increases the size of the packet which may exceed the Path MTU so that the packet will be dropped.

In the current network, the PMTU of most UNI (User-to-Network Interface) is configured as 1500 Bytes, due to the old link layer technology in the user side. In most scenarios, such as IP WAN and DCN, the PMTU of most NNI(Network-to-Network Interface) is configured as 9000 bytes, since most vendors have to support Jumpo frame(>9000 Bytes). Therefore, when a packet come from the UNI, the packet size is under 1500 bytes, which is far away from 9000 bytes even including the overhead of SRH. So the Path MTU is not a critical issue in the current network.

2. Forwarding Performance

As the size of the SRH overhead increases, it will bring burdens to the hardware forwarding or software forwarding, and it will have effect on the forwarding performance.

SRv6 can be deployed step-by-step in the networks while the hardware capability is being developed. Given the fact some vendors already supports the forwarding capability of up to 10 SIDs in the SRH now, the challenges can be mitigated in the near future. But SRv6 will be deployed in the wide network domains, the challenges to support more SIDs in SRH still exist.

3. Payload Efficiency

As the size of the SRH overhead increases, the ratio of the effective payload of a packet will be decreased. The SRH overhead will cause the waste of bandwidth.

According to the statistics information from AMS-IX <https://stats.ams-ix.net/sflow/index.html?type=;interval=monthly;counter=bps>, the average packet size is about 512 Bytes. From throughput (in bps) point of view, the packets large than 1024 bytes are more than 87% among the traffic. Given the typical packet size and traffic statistics information, the effect of payload efficiency can be under control with gradually introducing of SRv6. However, in the long term there may be requirements to insert up to 10 or more SIDs in an SRH which will low down the payload efficiency.

In summary, according to the above analysis, the issue of SRv6 SRH overhead can be under control in the short time. However, as the development of SRv6 in the wider network domains, more SIDs will be inserted in the SRH to support strict TE and other functionalities, it will propose more challenges for the hardware.

5. Gap Analysis of Existing Solutions

5.1. Binding SID

The Binding SID [RFC8402] is bound to an SR Policy, instantiation of which may involve a list of SIDs. Using BSID can shorten the SID list [I-D.peng-spring-srv6-compatibility], and BSID is widely deployed in the SR and SRv6 networks. However, the node that imposes the bound policy needs to store the SID list, meaning the node should maintain more states.

For example, the strict TE path <R1, R2, R3, R4, R5, R6, R7, R8, R9, R10> can be represented as a series of END.X SIDs allocated by the nodes, and the SID list can be represented as <R1-R2, R2-R3, R3-R4, R4-R5, R5-R6, R6-R7, R7-R8, R8-R9, R9-R10>. BSID1 is bound to an SID list <R2-R3, R3-R4, R4-R5, R5-R6>, BSID2 is bound to an SID list <R6-R7, R7-R8, R8-R9, R9-R10>. Therefore, the path can be represented as <R1-R2, BSID1, BSID2> by using the Binding SIDs. In this way, the SID number in the SRH is reduced from 9 to 3. While the drawback is that the states of Binding SIDs should be maintained at the mapping nodes R2 and R6.

```
           ++++++++++++++++++++++++++++++++++++++++++++++++++++
           +                                                  +
           +                                                  +
           +    BSID1                   BSID2                 +
    CPE1---R1---R2----R3----R4----R5----R6----R7----R8----R9--R10--CPE2
           +                                                  +
           +                                                  +
           +                                                  +
           ++++++++++++++++++++++++++++++++++++++++++++++++++++
```

Figure 2. Binding SID for Shorter the SID List

5.2. Loose Path TE

In some cases, if the strict TE path represented by an adjacency SID list is the same as the loose TE path represented by a node SID or prefix SID, the adjacency SID list can be replaced by the node SID or the prefix SID to reduce the number of SIDs. However, loose path TE can not guarantee the SLA of per-hop processing(bandwidth, delay, etc.) for the traffic.

For example, an SRv6 policy explicitly indicates a strict TE path by SID list <R1-R2, R2-R3, R3-R4, R4-R5, R5-R6, R6-R7, R7-R8, R8-R9, R9-R10>. If this path is the same as the SPF path of an END SID S10 of node R10, then this END SID S10 can be used for forwarding the traffic instead of the long SID list. However, if there are some SLA policy associated to the Adjacency SIDs along the path, then it can not be assured in best effort forwarding by using the END SID, even the packet is forwarded following the same path.

```
        ++++++++++++++++++++++++++++++++++++++++++++++++++++
        +     R11-------R12----R13                         +
        +     |          |      |                          +
        +     |          |      |                          + END SID S10
 CPE1---R1---R2----R3----R4----R5----R6----R7----R8----R9--R10--CPE2
        +           |                                  |   +
        +           |                                  |   +
        +           R14-------------------------------R15  +
        ++++++++++++++++++++++++++++++++++++++++++++++++++++
```

Figure 3. Binding SID for Shorter SID List

6. Requirements:

Based on the above typical scenario and gap analysis of existing solutions , this section lists the suggested requirements for Shorter SRv6 SID, which can be used to help the WG evaluate against the proposed solutions:

REQ#1: The Shorter SRv6 solution MUST be compatible with the basic SRv6. There are three basic Segment Routing over the IPv6 data-plane (SRv6) documents:

- o The Segment Routing (SR) architecture is defined in [RFC8402].

- o The IPv6 Segment Routing Header (SRH) is defined in [I-D.ietf-6man-segment-routing-header].

- o SRv6 Network Programming is defined in [I-D.ietf-spring-srv6-network-programming].

The Shorter SRv6 SID solution MUST be compatible with those defined in above documents.

REQ#2: The Shorter SRv6 SID solution MUST support Efficient SRv6 header compression.

When SRv6 is deployed, the SRv6 header overhead must be considered, as the size of the SRH may affect the forwarding performance. The solution MUST reduce the SRv6 SID size effectively.

REQ#3: The Shorter SRv6 SID solution MUST support source routing, SHOULD NOT introduce per-flow states on middle nodes.

Reducing the states on the middle nodes is the advantage of SR, and it should be maintained. New states should be introduced after carefully consideration if they are really needed.

REQ#4: A Shorter SRv6 SID solution SHOULD be routable as a Native IPv6 address for typical applications.

It is the key feature of SRv6 that an SRv6 SID can be routable as a native IPv6 address:

1. The feature guarantees the compatibility of SRv6 to IPv6.

2. Since an SRv6 SID is routable as a normal native IPv6 address, the traffic can be forwarded as the normal IPv6 traffic on the SRv6 unaware nodes. It simplifies the service provision since SRv6-based services can make use of the basic IPv6 reachability.

3. The routes of SRv6 SIDs can be aggregated since SRv6 SID can be routed as a native IPv6 address. This can reduce the number of forwarding entries and improve the scalability, especially in inter-AS networks scenarios.

4. Based on the native IPv6 routing, the SRv6 BE VPN can be deployed by only upgrading the VPN endpoint nodes. Also, SRv6 VPN traffic can be forwarded as the native IPv6 address without difficult configurations on the edge nodes in inter-domain scenarios.

Therefore, the shorter SRv6 SID SHOULD be routable as a Native IPv6 address.

Other scenarios will be considered in future, the solution should have the forward capabilities to support other scenarios.

REQ#5: The Shorter SRv6 SID solution CAN NOT require specific address planning or address type.

When deploying SRv6 in a network, the SIDs can be allocated from a SID space, the address block managed by the operators. The Shorter SID solution should support this as well. It MUST support flexible address planning as different networks have their own address allocation policy. The Shorter SID MUST NOT depend on some specific address type, and it SHOULD NOT introduce new address type in the network since this increases the complexities of configurations and operations, which will also bring troubles of OAM due to operators may have limited experience of it.

REQ#6: The Shorter SRv6 SID solution MUST be a Loseless Compression mechanism. The information carried by the shorter SID list in SRH MUST be equivalent to the original SID list.

The information can not be lost in compression since each SID represents the action and related services on a node, the Shorter SID solution MUST represent the same function. The format of the Shorter SID may be different from the original SRv6 SID, but the related function should be identical.

REQ#7: The Shorter SRv6 SID solution SHOULD support multiple functions, including END, END.X and END.T but not limit to them.

The solution MUST be scalable to support multiple functions and it SHOULD NOT be limited in only END, END.X and END.T, since there will be multiple SIDs to be introduced in the future, the solution should have the forward capabilities to support the new SIDs.

REQ#8: The Shorter SRv6 SID solution MUST be easy to implement and hardware-friendly(Including ASIC-based and NP-based hardware)

The Shorter SRv6 SID solution MUST be simple and easy to implement based on existing commercial hardware, which can be supported by multiple vendors instead of some specific vendors.

REQ#9: The Shorter SRv6 SID solution MUST be compatible with SRv6 header(SRH).

For support of the SRv6 network, Segment Routing Header (SRH) has been defined in [I-D.ietf-6man-segment-routing-header]. The Shorter SRv6 SID solution MUST be compatible with SRH.

REQ#10: The Shorter SRv6 SID solution SHOULD support to encode Compressed SRv6 Network Programming SIDs and SRv6 SIDs in a single SRH.

In an SR domain, there will be a scenario in which some nodes support Compressed SRv6, while others support IPv6 without SR extensions. The proposed solution MUST support this scenario.

REQ#11: The Shorter SRv6 SID solution MUST support super-large-scale networking and address planning.

Note: The operator suggest to reuse the current address assignment and planning, thus minimizing the impact on the network.

REQ#12: The Shorter SRv6 SID solution MUST have the ability to upgrade smoothly from SR-MPLS to SRv6.

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 the 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.

REQ#13: The Shorter SRv6 SID solution MUST support interworking between SRv6 and SR-MPLS domains in the network.

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.

7. The proposal solutions of shorter SRv6 SID

As we know, there are several proposals in the shorter SRv6 SID topic. This document tries to summarize these proposals here. Then we can discuss whether all the proposals can meet the requirements. And then we can look at the merits and costs of each solution. After that, we will possibly refine them, possibly converge on a single one, and probably drop multiples.

Here are the solutions that have been proposed:

o [I-D.filsfilscheng-spring-srv6-srh-comp-sl-enc] defines a compressed SRv6 network programming mechanism in order to reduce the overhead of SRv6 by introducing the Compressed Segment Identifier (C-SID). This solution leverages the SRv6 Network Programming model and adds new flavors to enable a compressed encoding of the SRv6 Segment-List in the SRH.

o [I-D.cl-spring-generalized-srv6-for-cmpr] proposes Generalized Segment Routing over IPv6 (G-SRv6) Networking Programming, which will remove the common prefix of SRv6 SIDs and supports to encode multiple types of Segments in an SRH, called Generalized SRH (G-SRH). These Segments can be called Generalized Segment, and the ID can be Generalized Segment Identifier (G-SID), which may include an SRv6 SID(128 bits), Shorter SID(32 bits or 16 bits).

o [I-D.filsfils-spring-net-pgm-extension-srv6-usid] extends SRv6 Network Programming with a new type of SRv6 SID behavior. A uSID carrier can be encoded in the Destination Address of an IPv6 header or at any position in the Segment List of an SRH.

o [I-D.decraene-spring-srv6-vlsid] extends SRH and SRv6 Network Programming to allow for SIDs of variable length, from 1 up to 128 bits. It is required to extend the control plane to advertise the SID length.

o [I-D.bonica-6man-comp-rtg-hdr] defines two new Routing header types. Collectively, they are called the Compressed Routing Headers (CRH). Individually, they are called CRH-16 and CRH-32. In the CRH, the Type-specific data field contains a list of Segment Identifiers (SIDs)(16bits/32bits).

o [I-D.mirsky-6man-unified-id-sr] extends the use of the flag of the SRH to unified identifiers encoded as shorter SID (such as

32-bits). It can be interworking with SR-MPLS. It is the earliest one, simple, and compatible well with original SRH.

8. IANA Considerations

This document has no requests to IANA.

9. Security Considerations

This document does not change the security considerations of SRv6, please refers to [RFC8402], [I-D.ietf-6man-segment-routing-header] and [I-D.ietf-spring-srv6-network-programming].

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Authors' Addresses

Weiqiang Cheng
China Mobile

Email: chengweiqiang@chinamobile.com

Chongfeng
China Telecom

Email: xiechf.bri@chinatelecom.cn

Ran Pang
China Unicom

Email: pangran@chinaunicom.cn

Zhenbin Li
Huawei Technologies

Email: lizhenbin@huawei.com

Ran Chen
ZTE Corporation

Email: chen.ran@zte.com.cn

Lijun
Unionpay

Email: zulijun@unionpay.com

Xiaodong Duan
China Mobile

Email: duanxiaodong@chinamobile.com

Greg Mirsk
ZTE Corporation

Email: gregimirsky@gmail.com

Darren Dukes
Cisco Systems, Inc

Email: ddukes@cisco.com

Shay Zadok
Broadcom

Email: shay.zadok@broadcom.com