           Using Flex-Algo for Segment Routing (SR) based Network Resource
                          Partition (NRP)
                draft-zhu-lsr-isis-sr-vtn-flexalgo-07

Abstract

   Enhanced VPNs aim to deliver VPN services with enhanced
   characteristics, such as guaranteed resources, latency, jitter, etc.,
   so as to support customers requirements for connectivity services
   with these enhanced characteristics. Enhanced VPN requires
   integration between the overlay VPN connectivity and the
   characteristics provided by the underlay network. A Network Resource
   Partition (NRP) is a subset of the network resources and associated
   policies on each of a connected set of links in the underlay network.
   An NRP could be used as the underlay to support one or a group of
   enhanced VPN services.

   In some network scenarios, each NRP can be associated with a unique
   Flexible Algorithm (Flex-Algo), which can provide constraint-path
   computation based on the customized topological constraints. This
   document specifies a mechanism to build Segment Routing (SR) based
   NRPs by combining SR Flex-Algo and IGP L2 bundles with minor
   extensions.

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1. Introduction

   Enhanced VPNs aim to deliver VPN services with enhanced
   characteristics, such as guaranteed resources, latency, jitter, etc.,
   so as to support customers requirements for connectivity services
   with these enhanced characteristics. Enhanced VPN requires
   integration between the overlay VPN connectivity and the
   characteristics provided by the underlay network.
   [I-D.ietf-teas-ietf-network-slices] discusses the general framework,
   components, and interfaces for requesting and operating network
   slices using IETF technologies. Network slice is considered as one
   target use case of enhanced VPNs.

   [I-D.ietf-teas-ietf-network-slices] also introduces the concept of
   the Network Resource Partition (NRP), which is a subset of the
   buffer/queuing/scheduling resources and associated policies on each
   of a connected set of links in an underlay network. An NRP can be
   associated with a logical network topology to select or specify the

set of links and nodes involved. [I-D.ietf-teas-enhanced-vpn]
specifies the framework of NRP-based enhanced VPNs and describes the
candidate component technologies in different network planes and
network layers. An NRP could be used as the underlay to meet the
requirement of one or a group of enhanced VPN services. To meet the
requirement of enhanced VPN services, a number of NRPs can be
created, each with a subset of network resources allocated on network
nodes and links in a customized topology of the physical network.

[I-D.ietf-spring-resource-aware-segments] introduces resource
awareness to Segment Routing (SR) [RFC8402]. The resource-aware SIDs
have additional semantics to identify the set of network resources
available for the packet processing action associated with the SIDs.
As described in [I-D.ietf-spring-sr-for-enhanced-vpn], the resource-
aware SIDs can be used to build SR-based NRPs with the required
network topology and network resource attributes to support enhanced
VPN services. In an SR-based data plane, Segment Identifiers (SIDs)
can be used to represent both the topological instructions and a
subset of network resources on the network nodes and links which are
allocated to an NRP. The SR SIDs and the associated topology and
resource attributes of an NRP need to be distributed using a control
plane.

In some network scenarios, the required number of NRPs could be
small, then it can be assumed that each NRP is associated with an
independent logical topology, and has a set of dedicated or shared
network resources. For such scenarios, this document describes a
simple mechanism to build Segment Routing (SR) based NRPs, by
combining SR Flex-Algo and IGP L2 bundles with minor extensions.
More specifically, each NRP is associated with a unique Flex-Algo,
and the subset of network resources allocated to the NRP are
instantiated using either virtual sub-interfaces or layer-2 member
links of L3 interfaces.

This document updates [RFC8668] by defining a new flag in the Parent
L3 Neighbor Descriptor in the L2 Bundle Member Attributes TLV.
[RFC8668] states that all bit fields not defined in that document
"MUST be set to zero on transmission and ignored on receipt".
Section 3 of this document defines a new flag and specifies when it
should be set and how it should be processed.

1.1. 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. Advertisement of NRP Topology Attributes

   [RFC9350] specifies the mechanism to provide distributed constraint-
   path computation, and the use of SR-MPLS prefix-SIDs and SRv6
   locators in data plane for steering traffic along the constrained
   paths.

   The Flex-Algo Definition (FAD) is the combination of calculation-
   type, metric-type and the topological constraints used for path
   computation. According to the network nodes' participation of a
   Flex-Algo, and the rules of including or excluding Admin Groups (i.e.
   colors) and Shared Risk Link Groups (SRLGs), the topology of an NRP
   can be described using the associated Flex-Algo. If each NRP is
   associated with a unique Flex-Algo, the Flex-Algo identifier could be
   used as the identifier of the NRP in the control plane.

   With the mechanisms defined in[RFC8667] [RFC9350], SR-MPLS prefix-SID
   advertisement can be associated with a constrained topology, which
   can be defined by a Flex-Algo. This allows the nodes to use the
   prefix-SIDs to steer traffic along distributed computed constraint
   paths according to the associated Flex-Algo in a particular topology.

   [RFC9352] specifies the IS-IS extensions to support SRv6 data plane,
   in which the SRv6 locators advertisement is associated with a
   constrained topology, which can be defined by a Flex-Algo. This
   allows the nodes to use the SRv6 locators to steer traffic along
   constraint paths computed using the Flex-Algo in the associated
   topology. In addition, SRv6 End SIDs and End.X SIDs which are
   associated with a Flex-Algo can be used to enforce traffic over the
   Loop-Free Alternatives (LFA) computed backup paths.

3. Advertisement of NRP Resource Attributes

   Each NRP can be allocated with a set of dedicated or shared network
   resources on a connected set of links in the underlay network.

   In order for a network controller or the ingress nodes to perform
   constraint based path computation for each NRP, the resource
   attributes of each NRP need to be advertised in the control plane,
   and distributed to the network controller. This way, the network
   controller or the ingress node can compute an SR-TE path in the NRP
   by taking both the Flex-Algo constraints and the resource attributes
   of the NRP into consideration.

   IS-IS L2 Bundle [RFC8668] was defined to advertise the link
   attributes of the layer-2 bundle member links. In this section, it
   is extended to advertise different subset of link resources and
   attributes associated with different NRPs on a layer-3 link.

The layer-3 link must have the capability of partitioning the link
resources into different subsets and allocate them to different NRPs
it participates in. Each partition of the link resources can be
instantiated as a virtual sub-interface, which can be seen as a
virtual layer-2 member link of the layer-3 link. When the layer-3
link is a layer-2 link bundle, the subset of link resources allocated
to a specific NRP may be provided by one or multiple physical layer-2
member links in the link bundle.

Normally the member links of a L2 link bundle are used in load-
balancing mode, some extension is needed to indicate that each member
link is used exclusively for traffic of a specific NRP. A new flag
"E" (Exclusive) is defined in the flag field of the Parent L3
Neighbor Descriptor in the L2 Bundle Member Attributes TLV (25).

```
     0 1 2 3 4 5 6 7
    +-+-+-+-+-+-+-+-+
    |P|E|         |
    +-+-+-+-+-+-+-+-+
```

E flag: When the E flag is set, it indicates each member link under
the Parent L3 link is used exclusively for one NRP, and load
balancing among the member links is not allowed. When the E flag is
clear, it indicates load balancing and sharing among the member links
are allowed.

Note that legacy implementations of [RFC8668] will set the E flag to
zero (clear) meaning that load balancing among the component links is
the default behavior. Further, when a legacy implementation receives
an E flag that is set, it will ignore the flag and so will assume
that load balancing among component links is allowed even when the
sender has requested it to not be used. The Flex-Algo associated
with the NRP can be defined that only nodes which support the E flag
and the mechanisms defined in this document are included in the
constraint-based path computation and packet forwarding of the NRP.

For each virtual or physical layer-2 member link under the layer-3
interface, the Admin Groups (AG) or Extended Admin Group (EAG)
attribute MUST be advertised using the mechanisms as defined in
[RFC8668]. Other TE attributes as defined in [RFC5305] such as the
Maximum Link Bandwidth attribute MAY be advertised for the
constraint-based path computation. The SR-MPLS Adj-SIDs or SRv6
End.X SIDs associated with each of the virtual or physical layer-2
member links SHOULD be advertised according to [RFC8668] and
[I-D.dong-lsr-l2bundle-srv6].

In order to correlate the virtual or physical layer-2 member links
with the associated Flex-Algo ID of the NRP, each NRP SHOULD be
assigned with a unique Admin Group (AG) or Extended Admin Group
(EAG), and the virtual or physical layer-2 member links associated
with this NRP SHOULD be configured with the AG or EAG of the NRP.
The AG or EAG of the parent layer-3 link SHOULD be set to the union
of all the AGs or EAGs of its virtual or physical layer-2 member
links. In the definition of the Flex-Algo which is associated with
the NRP, the Include-Any Admin Group with only the AG or EAG assigned
to the NRP SHOULD be used as the link constraints, the Include-All
Admin Goup or the Exclude Admin Group rules MUST NOT be used for a
Flex-Algo associated with an NRP. This is to ensure that the layer-3
link is included in the Flex-Algo constraint path computation for
each NRP it participates in.

4. Forwarding Plane Operations

   For the SR-MPLS data plane, a prefix SID is associated with the paths
   calculated using the Flex-Algo corresponding to the NRP. An outgoing
   layer-3 interface is determined for each path. In addition, the
   prefix-SID also steers the traffic to use the virtual or physical
   layer-2 member link which is associated with the NRP on the outgoing
   layer-3 interface for packet forwarding. A forwarding entry MUST be
   installed in the forwarding plane using the MPLS label that
   corresponds to the Prefix-SID associated with the Flex-algorithm
   corresponding to the NRP. The Adj-SIDs associated with the virtual
   or physical member links of an NRP MAY be used together with the
   prefix-SIDs of the same NRP to build SR-MPLS TE paths under the
   topological and resource constraints of the NRP.

   For the SRv6 data plane, an SRv6 Locator is a prefix which is
   associated with the paths calculated using the Flex-Algo
   corresponding to the NRP. An outgoing Layer-3 interface is
   determined for each path. In addition, the SRv6 Locator prefix also
   steers the traffic to use the virtual or physical layer-2 member link
   which is associated with the NRP on the outgoing layer-3 interface
   for packet forwarding. A forwarding entry for the SRv6 Locator
   prefix MUST be installed in the forwarding plane for the Flex-
   algorithm corresponding to the NRP.The End.XU SIDs associated with
   the virtual or physical member links of an NRP MAY be used together
   with other types of SRv6 SIDs of the same NRP to build SRv6 paths
   under the topological and resource constraints of the NRP.

5. Scalability Considerations

   The mechanism described in this document assumes that each NRP is
   associated with a unique Flex-Algo, so that the Flex-Algo IDs can be
   reused to identify the NRPs in the control plane. While this brings
   the benefit of simplicity, it also has some limitations. For
   example, it means that even if multiple NRPs share the same
   constrained topology, they would still need to be identified using
   different Flex-Algos in the control plane, then independent path
   computation needs to be executed for each NRP. Thus the number of
   NRPs supported in a network may be dependent on the number of
   topologies supported, which is related to both the number of
   topologies supported in the protocol and the control plane overhead
   which the network nodes could accomodate. The mechanism described in
   this document is considered useful for network scenarios in which the
   required number of NRPs is small, as minor control protocol extension
   is required. For network scenarios where the number of required NRPs
   is large, more scalable solution would be needed, which may require
   further protocol extensions and enhancements. A detailed analysis
   about the NRP scalability and the possible optimizations for
   supporting a large number of NRPs is described in
   [I-D.ietf-teas-nrp-scalability].

6. Security Considerations

   This document introduces no additional security vulnerabilities to
   IS-IS.

   The mechanism proposed in this document is subject to the same
   vulnerabilities as any other protocol that relies on IGPs.

7. IANA Considerations

   This document does not request any IANA actions.

8. Acknowledgments

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   Farrel and Gyan Mishra for the review and discussion of this
   document.

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