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IGP Flexible Algorithms (Flex-Algorithm) In IP Networks
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Abstract

An IGP Flexible Algorithm (Flex-Algorithm) allows IGP to compute constraint-based paths. As currently defined, IGP Flex-Algorithm is used with Segment Routing (SR) data planes - SR MPLS and SRv6. Therefore, Flex-Algorithm cannot be deployed in the absence of SR.

This document extends IGP Flex-Algorithm, so that it can be used for regular IPv4 and IPv6 prefixes. This allows Flex-Algorithm to be deployed in any IP network, even in the absence of SR.

Status of This Memo

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1. Introduction

An IGP Flex-Algorithm as specified in [I-D.ietf-lsr-flex-algo] computes a constraint-based path to:

* All Flex-Algorithm specific Prefix Segment Identifiers (SIDs) [RFC8402].

* All Flex-Algorityhm specific SRv6 Locators [RFC8986].

Therefore, Flex-Algorithm cannot be deployed in the absence of SR and SRv6.

This document extends Flex-Algorithm, allowing it to compute paths to:

* An IPv4 [RFC0791] address.

* An IPv6 [RFC8200] address.

This allows Flex-Algorithm to be deployed in any IP network, even in the absence of SR and SRv6.

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. Egress Node Procedures

Network operators configure multiple loopback interfaces on an egress node. They associate one or more IP addresses with each loopback interface and one Flex-Algorithm with each IP address.

If a packet is sent to a loopback address, and the loopback address is not associated with a Flex-Algorithm, the packet follows the IGP least-cost path to the egress node. If a packet is sent to a loopback address, and the loopback address is associated with a Flex-Algorithm, the packet follows the constraint-base path that the Flex-Algorithm calculated.

4. Advertising Flex-Algorithm Definitions (FAD)

To guarantee loop free forwarding, all routers that participate in a Flex-Algorithm MUST agree on the Flex-Algorithm Definition (FAD).

Selected nodes within the IGP domain MUST advertise FADs as described in Sections 5, 6 and 7 of [I-D.ietf-lsr-flex-algo].

5. Advertising IP Flex-Algorithm Participation

A node may use various algorithms when calculating paths to nodes and prefixes. Algorithm values are defined in the IGP Algorithm Type Registry [IANA-ALG].

A node MUST participate in a Flex-Algorithm to be:

* able to compute path for such Flex-Algorithm

* be part of the topology for such Flex-Algorithm

Flex-Algorithm participation MUST be advertised for each Flex-Algorithm application independently, as specified in Section 10.2 of [I-D.ietf-lsr-flex-algo]. Using Flex-Algorithm for regular IPv4 and IPv6 prefixes represents a new Flex-Algorithm application (IP Flex-Algorithm), and as such the Flex-Algorithm participation for the IP Flex-Algorithm application MUST be signalled independently of any other Flex-Algorithm applications (e.g. SR).

Following sections describe how the IP Flex-Algorithm participation is advertised in IGP protocols.

5.1. The ISIS IP Algorithm Sub-TLV

The ISIS IP Algorithm Sub-TLV is a sub-TLV of the ISIS Router Capability TLV [RFC7981] and has the following format:

```
 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    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Algorithm 1   |  Algorithm 2  | Algorithm ... |  Algorithm n  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1: ISIS IP Algorithm Sub-TLV

* Type: IP Algorithm Sub-TLV (Value 29)

* Length: Variable

* Algorithm (1 octet): value from 1 to 255.

The IP Algorithm Sub-TLV MUST be propagated throughout the level and MUST NOT be advertised across level boundaries. Therefore, the S bit in the Router Capability TLV, in which the IP Algorithm Sub-TLV is advertised, MUST NOT be set.

The IP Algorithm Sub-TLV is optional. It MUST NOT be advertised more than once at a given level. A router receiving multiple IP Algorithm sub-TLVs from the same originator SHOULD select the first advertisement in the lowest-numbered LSP and subsequent instances of the IP Algorithm Sub-TLV MUST be ignored.

The IP Algorithm Sub-TLV advertises the participation in Flex-Algorithms, and MUST NOT impact the router participation in default algorithm 0. The IP Algorithm Sub-TLV could be used to advertise support for non-zero standard algorithms, but that is outside the scope of this document.

The IP Flex-Algorithm participation advertised in ISIS IP Algorithm Sub-TLV is topology independent. When a router advertises participation in ISIS IP Algorithm Sub-TLV, the participation applies to all topologies in which the advertising node participates.

5.2. The OSPF IP Algorithm TLV

The OSPF IP Algorithm TLV is a top-level TLV of the Router Information Opaque LSA [RFC7770] and has the following format:

```
 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            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Algorithm 1 | Algorithm...  |   Algorithm n |               |
```

```
   +-                                                             -+
   |                                                               |
   +                                                               +
```

Figure 2: OSPF IP Algorithm TLV

* Type: IP Algorithm TLV (Value TBD by IANA)

* Length: Variable

* Algorithm (1 octet): value from 1 to 255.

The IP Algorithm TLV is optional. It SHOULD only be advertised once in the Router Information Opaque LSA.

When multiple IP Algorithm TLVs are received from a given router, the receiver MUST use the first occurrence of the TLV in the Router Information Opaque LSA. If the IP Algorithm TLV appears in multiple Router Information Opaque LSAs that have different flooding scopes, the IP Algorithm TLV in the Router Information Opaque LSA with the area-scoped flooding scope MUST be used. If the IP Algorithm TLV appears in multiple Router Information Opaque LSAs that have the same flooding scope, the IP Algorithm TLV in the Router Information (RI) Opaque LSA with the numerically smallest Instance ID MUST be used and subsequent instances of the IP Algorithm TLV MUST be ignored.

The RI LSA can be advertised at any of the defined opaque flooding scopes (link, area, or Autonomous System (AS)). For the purpose of IP Algorithm TLV advertisement, area-scoped flooding is REQUIRED.

The IP Algorithm TLV advertises the participation in Flex-Algorithms, and MUST NOT impact the router participation in default algorithm 0. The IP Algorithm TLV could be used to advertise support for non-zero standard algorithms, but that is outside the scope of this document.

The IP Flex-Algorithm participation advertised in OSPF IP Algorithm TLV is topology independent. When a router advertises participation in OSPF IP Algorithm TLV, the participation applies to all topologies in which the advertising node participates.

6. Advertising IP Flex-Algorthm Reachability

To be able to associate the prefix with the Flex-Algorithm, the existing prefix reachability advertisements can not be used, because they advertise the prefix reachability in default algorithm 0. Instead, a new IP Flex-Algorithm reachability advertisements are defined in ISIS and OSPF.

The M-flag in FAD is not applicable to IP Algorithm Prefixes. Any IP Algorithm Prefix advertisement includes the Algorithm and Metric fields. When IP Algorithm Prefix is advertised between areas or domains, the metric field in the IP Algorithm Prefix advertisement MUST be used irrespective of the M-flag in the FAD advertisement.

Two new top-level TLVs are defined in ISIS [ISO10589] to advertise prefix reachability associated with a Flex-Algorithm.

* The IPv4 Algorithm Prefix Reachability TLV

* The IPv6 Algorithm Prefix Reachability TLV

New top-level TLV of OSPFv2 Extended Prefix Opaque LSA [RFC7684] is defined to advertise prefix reachability associated with a Flex-Algorithm in OSPFv2.

6.1. The ISIS IPv4 Algorithm Prefix Reachability TLV

A new top level TLV is defined for advertising IPv4 Flex-Algorithm Prefix Reachability in ISIS - IPv4 Algorithm Prefix Reachability TLV.

This new TLV shares the sub-TLV space defined for TLVs 135, 235, 236 and 237.

The ISIS IPv4 Algorithm Prefix Reachability TLV has the following format:

```
 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    |R|R|R|R|    MTID               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 3: ISIS IPv4 Algorithm Prefix Reachability TLV

* Type: IPv4 Algorithm Prefix Reachability TLV (Value 126).

* Length: variable.

* R bits (4 bits): reserved for future use. They MUST be set to zero on transmission and MUST be ignored on receipt.

* MTID (12 bits): Multitopology Identifier as defined in [RFC5120]. Note that the value 0 is legal.

Followed by one or more prefix entries of the form:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            Metric                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Flags       |  Algorithm    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Pfx Length   |  Prefix (variable)...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Sub-tlv-len  |         Sub-TLVs (variable) . . .             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4: ISIS IPv4 Algorithm Prefix Reachability TLV

* Metric (4 octets): Metric information.

* Flags (1 octet):

```
 0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+
|D|  Reserved   |
+-+-+-+-+-+-+-+-+
```

D-flag: When the Prefix is leaked from level-2 to level-1, the

D bit MUST be set. Otherwise, this bit MUST be clear.

Prefixes with the D bit set MUST NOT be leaked from level-1 to level-2. This is to prevent looping.

* Algorithm (1 octet): Associated Algorithm from 1 to 255.

* Prefix Len (1 octet): Prefix length measured in bits.

* Prefix (variable length): Prefix mapped to Flex-Algorithm.

* Optional Sub-TLV-length (1 octet): Number of octets used by sub-TLVs

* Optional sub-TLVs (variable length).

A router receiving multiple IPv4 Algorithm Prefix Reachability advertisements for the same prefix, from the same originator, each with a different Algorithm, MUST select the first advertisement in the lowest-numbered LSP and ignore any subsequent IPv4 Algorithm Prefix Reachability advertisements for the same prefix for any other Algorithm.

A router receiving multiple IPv4 Algorithm Prefix Reachability advertisements for the same prefix, from different originators, each with a different Algorithm, MUST ignore all of them and MUST NOT install any forwarding entries based on these advertisements.

In cases where a prefix advertisement is received in both a IPv4 Prefix Reachability TLV and an IPv4 Algorithm Prefix Reachability TLV, the IPv4 Prefix Reachability advertisement MUST be preferred when installing entries in the forwarding plane.

6.2. The ISIS IPv6 Algorithm Prefix Reachability TLV

The ISIS IPv6 Algorithm Prefix Reachability TLV is identical to the ISIS IPv4 Algorithm Prefix Reachability TLV, except that it has a unique type. The type is 127.

A router receiving multiple IPv6 Algorithm Prefix Reachability advertisements for the same prefix, from the same originator, each with a different Algorithm, MUST select the first advertisement in the lowest-numbered LSP and ignore any subsequent IPv6 Algorithm Prefix Reachability advertisements for the same prefix for any other Algorithm.

A router receiving multiple IPv6 Algorithm Prefix Reachability advertisements for the same prefix, from different originators, each with a different Algorithm, MUST ignore all of them and MUST NOT install any forwarding entries based on these advertisements.

In cases where a prefix advertisement is received in both a IPv6 Prefix Reachability TLV and an IPv6 Algorithm Prefix Reachability TLV, the IPv6 Prefix Reachability advertisement MUST be preferred when installing entries in the forwarding plane.

6.3. The OSPFv2 IP Algorithm Prefix Reachability Sub-TLV

A new Sub-TLV of OSPFv2 Extended Prefix TLV is defined for advertising IP Algorithm Prefix Reachability in OSPFv2 - OSPFv2 IP Algorithm Prefix Reachability Sub-TLV.

The OSPFv2 IP Algorithm Prefix Reachability Sub-TLV has the following format:

```
 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            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     MT-ID     |  Algorithm    |           Reserved            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                              Metric                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5: OSPFv2 IP Algorithm Prefix Reachability Sub-TLV

* Type (2 octets) : The value is TBD.

* Length (1 octet): 8

* MT-ID (1 octet): Multi-Topology ID as defined in [RFC8402]

* Algorithm (1 octet): Associated Algorithm from 1 to 255. Algorithm values are defined in the IGP Algorithm Type registry. If the value of Algorithm is 0 the TLV MUST be ignored.

* Reserved: (2 octets). SHOULD be set to 0 on transmission and MUST be ignored on reception.

* Metric (3 octets): The algorithm specific metric value.

A OSPFv2 router receiving multiple OSPFv2 IP Algorithm Prefix Reachability Sub-TLVs in the same OSPFv2 Extended Prefix TLV, MUST select the first advertisement of this Sub-TLV and MUST ignore all remaining occurences of this Sub-TLV in the OSPFv2 Extended Prefix TLV.

A OSPFv2 router receiving multiple OSPFv2 IP Algorithm Prefix Reachability TLVs for the same prefix, from different originators, each with a different Algorithm, MUST ignore all of them and MUST NOT install any forwarding entries based on these advertisements.

In cases where a prefix advertisement is received in any of the LSAs advertising the prefix reachability for algorithm 0 (Router-LSA, Summary-LSA, AS-external-LSA or NSSA AS-external LSA) and in an OSPFv2 IP Algorithm Prefix Reachability TLV, only the prefix reachability advertisement for algorithm 0 MUST be used and all occurences of the OSPFv2 IP Algorithm Prefix Reachability TLV MUST be ignored.

6.4. The OSPFv3 IP Algorithm Prefix Reachability Sub-TLV

The OSPFv3 IP Algorithm Prefix Reachability Sub-TLV is defined for advertisement of the IP Algorithm Prefix Reachability in OSPFv3.

The OSPFv3 IP Algorithm Prefix Reachability Sub-TLV is a sub-TLV of the following OSPFv3 TLVs defined in [RFC8362]:

* Intra-Area-Prefix TLV

* Inter-Area-Prefix TLV

* External-Prefix TLV

The format of OSPFv3 IP Algorithm Prefix Reachability Sub-TLV is shown below:

```
 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            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Algorithm    |                 Metric                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 6: OSPFv3 Algorithm Prefix Sub-TLV

Where:

Type (2 octets): The value is TBD.

Length (2 octets): 4.

Algorithm (1 octet): Associated Algorithm from 1 to 255. Algorithm values are defined in the IGP Algorithm Type registry. If the value of Algorithm is 0 the TLV MUST be ignored.

Metric (3 octets): The algorithm specific metric value.

When the OSPFv3 IP Algorithm Prefix Reachability Sub-TLV is present, the metric value in its parent TLV MUST be set to LSInfinity ([RFC2328]). If the metric value in the parent TLV is not set to LSInfinity, the OSPFv3 IP Algorithm Prefix Sub-TLV MUST be ignored by the receiver.

A OSPFv3 router receiving multiple OSPFv3 IP Algorithm Prefix Reachability Sub-TLVs in the same parent TLV, MUST select the first advertisement of this Sub-TLV and MUST ignore all remaining occurences of this Sub-TLV in the parent TLV.

A OSPFv3 router receiving multiple OSPFv3 IP Algorithm Prefix Reachability TLVs for the same prefix, from different originators, each with a different Algorithm, MUST ignore all of them and MUST NOT install any forwarding entries based on these advertisements.

In cases where a prefix advertisement is received in any of the TLVs advertising the prefix reachability for algorithm 0 (Intra-Area-Prefix TLV, Inter-Area-Prefix TLV, or External-Prefix TLV) with metric other then LSInfinity, all OSPFv3 IP Algorithm Prefix TLVs received for the prefix MUST be ignored.

6.5. The OSPF IP Flexible Algorithm ASBR Metric Sub-TLV

Section 10.2 of the [I-D.ietf-lsr-flex-algo] defines the OSPF Flexible Algorithm ASBR Metric Sub-TLV (FAAM) that is used by OSPFv2 and OSPFv3 to advertise Flex-Algorithm specific metric associated with a given ASBR reachability advertisement by an ABR.

As described in section 11 of [I-D.ietf-lsr-flex-algo] each application signals the participation independently. IP Flex-Algorithm participation is signalled independently of the Segment Routing (SR) Flex-Algorithm participation. As a result, the calculated topologies for SR and IP Flex-Algorithm could be different. Such difference prevents the usage of FAAM for the purpose of the IP Flex-Algorithm.

The OSPF IP Flexible Algorithm ASBR Metric (IPFAAM) Sub-TLV is defined for the advertisement of the IP Flex-Algorithm specific metric associated with an ASBR by the ABR.

The IPFAAM Sub-TLV is a Sub-TLV of the:

- OSPFv2 Extended Inter-Area ASBR TLV as defined in [I-D.ietf-lsr-flex-algo]

- OSPFv3 Inter-Area-Router TLV defined in [RFC8362]

OSPF IPFAAM Sub-TLV has the following format:

```
 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            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Algorithm   |                   Reserved                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            Metric                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

where:

Type (2 octets): TBD for OSPFv2, TBD for OSPFv3.

Length (2 octets): 8.

Algorithm (1 octet): Associated Algorithm from 1 to 255. Algorithm values are defined in the IGP Algorithm Type registry. If the value of Algorithm is 0 the TLV MUST be ignored.

Reserved: (3 octets). SHOULD be set to 0 on transmission and MUST be ignored on reception.

Metric (4 octets): The algorithm specific metric value.

The usage of the IPFAAM Sub-TLV is similar to the usage of the FAAM Sub-TLV defined in [I-D.ietf-lsr-flex-algo], but it is used to advertise IP Flex-Algorithm metric.

An OSPF ABR MUST include the OSPF IPFAAM Sub-TLVs as part of the ASBR reachability advertisement between areas for every IP Flex-Algorithm in which it participates and the ASBR is reachable in.

FAAM Sub-TLV as defined in [I-D.ietf-lsr-flex-algo] MUST NOT be used during IP Flex-Algorithm path calculation, IPFAAM Sub-TLV MUST be used instead.

7. Calculating of IP Flex-Algorthm Paths

IP Flex-Algorthm is considered as yet another application of the Flex-Algorithm as described in Section 10 and Section 12 of the [I-D.ietf-lsr-flex-algo].

Participation for the IP Flex-Algorithm is signalled as described in Section 5 and is specific to the IP Flex-Algorithm application.

Calculation of IP Flex-Algorithm paths follows the Section 12 of [I-D.ietf-lsr-flex-algo]. This computation uses the IP Flex-Algorithm participation and is independent of the Flex-Algorithm calculation done for any other Flex-Algorithm applications (e.g. SR, SRv6).

IP Flex-Algorithm application only considers participating nodes during the Flex-Algorithm calculation. When computing paths for a given Flex-Algorithm, all nodes that do not advertise participation for IP Flex-Algorithm, as described in Section 5, MUST be pruned from the topology.

8. IP Flex-Algorthm Forwarding

IP Algorithm Prefix Reachability advertisement as described in Section 5 includes the MTID value that associates the prefix with a specific topology. Algorithm Prefix Reachability advertisement also includes an Algorithm value that explicitly associates the prefix with a specific Flex-Algorithm. The paths to the prefix MUST be calculated using the specified Flex-Algorithm in the associated topology.

Forwarding entries for the IP Flex-Algorithm prefixes advertised in IGPs MUST be installed in the forwarding plane of the receiving IP Flex-Algorithm prefix capable routers when they participate in the associated topology and algorithm. Forwarding entries for IP Flex-Algorithm prefixes associated with Flex-Algorithms in which the node is not participating MUST NOT be installed in the forwarding plane.

When the IP Flex-Algorithm prefix is associated with a Flex-Algorithm, LFA paths to the prefix MUST be calculated using such Flex-Algorithm in the associated topology, to guarantee that they follow the same constraints as the calculation of the primary paths.

9. Deployment Considerations

IGP Flex-Algorithm can be used by many applications. Original specification was done for SR and SRv6, this specification adds IP as another application that can use IGP Flex-Algorithm. Other applications may be defined in the future. This section provides some details about the coexistence of the various applications of the IGP Flex-Algorithm.

Flex-Algorithm definition (FAD), as described in [I-D.ietf-lsr-flex-algo], is application independent and is used by

all Flex-Algorithm applications.

Participation in the Flex-Algorithm, as described in [I-D.ietf-lsr-flex-algo], is application specific.

Calculation of the flex-algo paths is application specific and uses application specific participation advertisements.

Application specific participation and calculation guarantee that the forwarding of the traffic over the Flex-Algorithm application specific paths is consistent between all nodes over which the traffic is being forwarded.

Multiple application can use the same Flex-Algorithm value at the same time and and as such share the FAD for it. For example SR-MPLS and IP can both use such common Flex-Algorithm. Traffic for SR-MPLS will be forwarded based on Flex-algorithm specific SR SIDs. Traffic for IP Flex-Algorithm will be forwarded based on Flex-Algorithm specific prefix reachability announcements.

10. Protection

In many networks where IGP Flexible Algorithms are deployed, IGP restoration will be fast and additional protection mechanisms will not be required. IGP restoration may be enhanced by Equal Cost Multipath (ECMP).

In other networks, operators can deploy additional protection mechanisms. The following are examples:

* Loop Free Alternates (LFA) [RFC5286]

* Remote Loop Free Alternates (R-LFA) [RFC7490]

LFA and R-LFA computations MUST be restricted to the flex-algo topology and the computed backup nexthops should be programmed for the IP flex-algo prefixes.

11. IANA Considerations

This specification updates the OSPF Router Information (RI) TLVs Registry as follows:

Value	TLV Name	Reference
TBD	IP Algorithm TLV	This Document Section 5.2

Table 1

This document also updates the "Sub-TLVs for TLV 242" registry as follows:

Value	TLV Name	Reference
29	IP Algorithm Sub-TLV	This Document Section 5.1

Table 2

This document also updates the "ISIS TLV Codepoints Registry" registry as follows:

Value	TLV Name	IIH	LSP	SNP	Purge	Reference
126	IPv4 Algorithm Prefix Reachability TLV	N	Y	N	N	This document, Section 6.1
127	IPv6 Algorithm Prefix Reachability TLV	N	Y	N	N	This document, Section 6.2

Table 3

This document updates the "OSPFv2 Extended Prefix TLV Sub-TLVs" registry as follows:

Value	TLV Name	Reference
TBD	OSPFv2 IP Algorithm Prefix Reachability TLV	This Document, Section 6.3

Table 4

This document updates the "OSPFv3 Extended-LSA Sub-TLVs" registry as follows:

Value	TLV Name	Reference
TBD	OSPFv3 IP Algorithm Prefix Reachability Sub-TLV	This Document, Section 6.4
TBD	OSPFv3 IP Flexible Algorithm ASBR Metric Sub-TLV	This Document, Section 6.5

Table 5

This document updates the "OSPFv2 Extended Inter-Area ASBR Sub-TLVs" registry as follows:

Value	TLV Name	Reference
2	OSPF IP Flexible Algorithm ASBR Metric Sub-TLV	This Document, Section 6.5

Table 6

12. Security Considerations

This document inherits security considerations from [I-D.ietf-lsr-flex-algo].

13. Acknowledgements

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14. References

14.1. Normative References

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