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RFC 9917
IGP Flexible Algorithms Reverse Affinity Constraint

Abstract

An IGP Flexible Algorithm (Flex-Algorithm) enables the computation of constraint-based paths within an IGP domain, allowing operators to influence path selection according to administrative policies. This document defines an extension to Flex-Algorithm that allows the inclusion or exclusion of links from path computation based on Administrative Groups (also known as link affinities) associated with the reverse direction of the path under computation.

This extension enhances the path selection capabilities of Flex-Algorithm by enabling reverse-affinity-based constraints, which are particularly useful for scenarios where path symmetry or directional link attributes are operationally significant.

This document updates RFCs 9350 and 9843 by introducing the new IANA registry that specifies the ordered set of rules that are used to prune links from the topology during the Flex-Algorithm path computation.

Status of This Memo

This is an Internet Standards Track document.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Further information on Internet Standards is available in Section 2 of RFC 7841.

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at https://www.rfc-editor.org/info/rfc9917.

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1. Introduction

IGP protocols historically computed the best paths over the network solely based on the IGP metric assigned to the links. An IGP Flex-Algorithm as specified in [RFC9350] allows IGPs to compute constraint-based paths. Several mechanisms to include or exclude the link during the Flex-Algorithm path calculation have been defined already:

- link inclusion or exclusion based on the presence of a specific Admin Group(s) [RFC9350]
- link exclusion based on the presence of a specific Shared Risk Link Group (SRLG) [RFC9350]
- link exclusion based on minimum bandwidth [RFC9843]
- link exclusion based on maximum delay [RFC9843]

This document extends IGP Flex-Algorithm with additional constraints for inclusion or exclusion of links in the path based on Admin Groups associated with the reverse direction of the Shortest Path First (SPF) computation.

This document updates [RFC9350] and [RFC9843] by creating the new IANA registry that specifies the ordered set of rules that are used to prune links from the topology during the Flex-Algorithm path computation (refer to Section 12).

The term OSPF in this document is used to cover both OSPFv2 and OSPFv3 protocols.

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. Use Case Example

The Flexible Algorithm Definition (FAD) can specify Extended Administrative Groups that are used by the operator to include or exclude links during the Flex-Algorithm path computation [RFC9350]. These link Extended Administrative Groups are checked in the path direction of the SPF computation, e.g., in the direction from the root vertex toward vertices of increasing distance.

In certain scenarios, it is beneficial to evaluate the Extended Administrative Groups associated with the reverse direction of a link, rather than solely those in the direction of path computation. Consider a point-to-point link represented as a pair of directed edges between two nodes, A and B. When computing a path from A to B, issues such as input errors on the link, detectable only at the receiving node B, may be operationally significant. An operator might monitor metrics like Cyclic Redundancy Check (CRC) errors or other input-related faults at node

B and apply thresholds over a defined observation period. If such a threshold is exceeded, node B may locally assign specific Extended Administrative Groups to the link in the direction from B to A.

To accommodate this operational intent, the Flex-Algorithm can be extended to inspect the Extended Administrative Groups of the reverse-direction edge (from B to A) when evaluating the forward-direction edge (from A to B) during path computation. This enables the exclusion of links from the computed topology based on conditions detected at the far end of the link, improving network reliability and policy control.

4. Deployment Consideration

Threshold-based setting of the link Extended Administrative Groups must be done with care to avoid excessive flooding and constant Flex-Algorithm path recalculation.
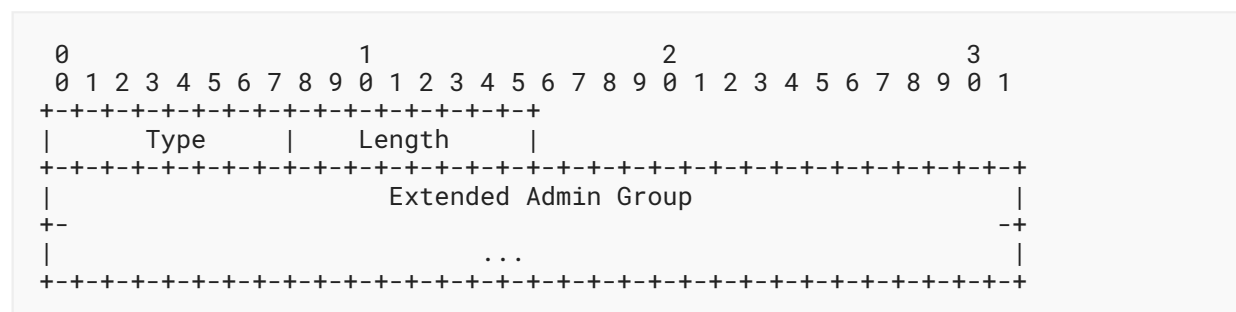
One possible approach is to use two different thresholds when setting and unsetting the Extended Administrative Group on the link. For example, when setting the Extended Administrative Group on the link based on the percentage of certain incoming errors, higher threshold is used for setting and lower threshold is used for unsetting the Extended Administrative Group on the link.

Many implementations provide a throttling mechanism that limits the rate at which the Label Switched Path (LSP) in case of IS-IS, or Link State Advertisement (LSA) in case of OSPFv2 and OSPFv3, is updated at the originator. Such mechanism is typically not specific to any particular link attribute, but rather considers any change in the LSP or LSA. Usage of such throttling mechanism can also be used to avoid frequent changes in the setting of the Extended Administrative Group on a link to affect the stability of the receivers.

5. IS-IS Flexible Algorithm Exclude Reverse Admin Group Sub-TLV

The IS-IS Flexible Algorithm Exclude Reverse Admin Group (FAERAG) Sub-TLV is used to advertise the exclude rule that is used during the Flex-Algorithm path calculation as specified in Section 11.

The IS-IS FAERAG Sub-TLV is a sub-TLV of the IS-IS FAD Sub-TLV. It 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     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Extended Admin Group                       |
+-                                                             -+
|                            ...                                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

where:

Type (1 octet):   10

Length (1 octet):   Variable, dependent on the size of the Extended Admin Group. The length **MUST** be a multiple of 4 octets. If the length is not a multiple of 4 octets, the entire sub-TLV **MUST** be ignored by the receiver.

Extended Administrative Group: Extended Administrative Group as defined in [RFC7308].

The IS-IS FAERAG Sub-TLV **MUST NOT** appear more than once in a single IS-IS FAD Sub-TLV. If it appears more than once, the IS-IS FAD Sub-TLV **MUST** be ignored by the receiver.

The IS-IS FAERAG Sub-TLV **MUST NOT** appear more than once in the set of FAD Sub-TLVs for a given Flex-Algorithm from a given IS. If it appears more than once in such set, the IS-IS FAERAG Sub-TLV in the first occurrence in the lowest-numbered LSP from a given IS **MUST** be used and any other occurrences **MUST** be ignored by the receiver.

6. IS-IS Flexible Algorithm Include-Any Reverse Admin Group Sub-TLV

The IS-IS Flexible Algorithm Include-Any Reverse Admin Group Sub-TLV is used to advertise the include-any rule that is used during the Flex-Algorithm path calculation as specified in Section 11.

The format of the IS-IS Flexible Algorithm Include-Any Reverse Admin Group Sub-TLV is identical to the format of the FAERAG Sub-TLV in Section 5.

IANA has assigned Type value of 11 for the IS-IS Flexible Algorithm Include-Any Reverse Admin Group Sub-TLV.

The IS-IS Flexible Algorithm Include-Any Reverse Admin Group Sub-TLV **MUST NOT** appear more than once in a single IS-IS FAD Sub-TLV. If it appears more than once, the IS-IS FAD Sub-TLV **MUST** be ignored by the receiver.

The IS-IS Flexible Algorithm Include-Any Reverse Admin Group Sub-TLV **MUST NOT** appear more than once in the set of FAD Sub-TLVs for a given Flex-Algorithm from a given IS. If it appears more than once in such set, the IS-IS Flexible Algorithm Include-Any Reverse Admin Group Sub-TLV in the first occurrence in the lowest-numbered LSP from a given IS **MUST** be used and any other occurrences **MUST** be ignored by the receiver.

7. IS-IS Flexible Algorithm Include-All Reverse Admin Group Sub-TLV

The IS-IS Flexible Algorithm Include-All Reverse Admin Group Sub-TLV is used to advertise the include-all rule that is used during the Flex-Algorithm path calculation as specified in Section 11.

The format of the IS-IS Flexible Algorithm Include-All Reverse Admin Group Sub-TLV is identical to the format of the FAERAG Sub-TLV in Section 5.

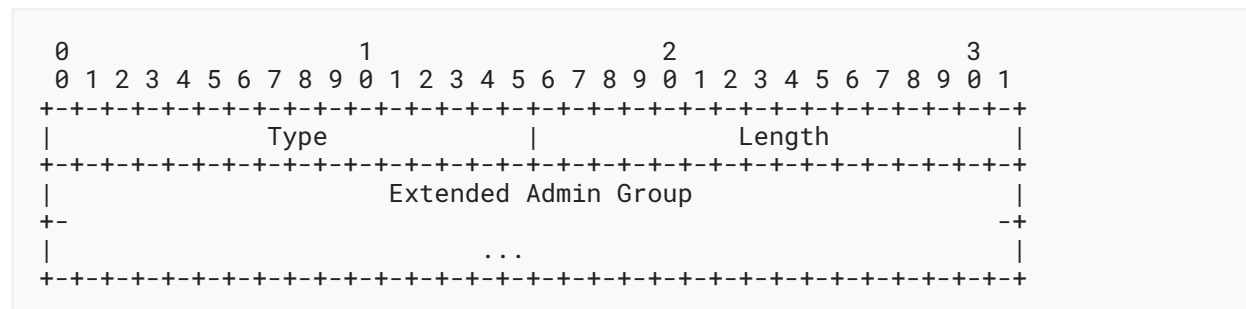IANA has assigned Type value of 12 for the IS-IS Flexible Algorithm Include-All Reverse Admin Group Sub-TLV.

The IS-IS Flexible Algorithm Include-All Reverse Admin Group Sub-TLV **MUST NOT** appear more than once in a single IS-IS FAD Sub-TLV. If it appears more than once, the IS-IS FAD Sub-TLV **MUST** be ignored by the receiver.

The IS-IS Flexible Algorithm Include-All Reverse Admin Group Sub-TLV **MUST NOT** appear more than once in the set of FAD Sub-TLVs for a given Flex-Algorithm from a given IS. If it appears more than once in such set, the IS-IS Flexible Algorithm Include-All Reverse Admin Group Sub-TLV in the first occurrence in the lowest-numbered LSP from a given IS **MUST** be used and any other occurrences **MUST** be ignored by the receiver.

8. OSPF Flexible Algorithm Exclude Reverse Admin Group Sub-TLV

The OSPF Flexible Algorithm Exclude Reverse Admin Group (FAERAG) Sub-TLV is used to advertise the exclude rule that is used during the Flex-Algorithm path calculation as specified in Section 11.

The OSPF FAERAG Sub-TLV is a sub-TLV of the OSPF FAD TLV. It 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            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Extended Admin Group                       |
+-                                                             -+
|                             ...                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

where:

Type (2 octets):   10

Length (2 octets):   Variable, dependent on the size of the Extended Admin Group. The length **MUST** be a multiple of 4 octets. If the length is not a multiple of 4 octets, the entire sub-TLV **MUST** be ignored by the receiver.

Extended Administrative Group: Extended Administrative Group as defined in [RFC7308].

The OSPF FAERAG Sub-TLV **MUST NOT** appear more than once in an OSPF FAD TLV. If it appears more than once, the OSPF FAD TLV **MUST** be ignored by the receiver.

9. OSPF Flexible Algorithm Include-Any Reverse Admin Group Sub-TLV

The OSPF Flexible Algorithm Include-Any Reverse Admin Group Sub-TLV is used to advertise the include-any rule that is used during the Flex-Algorithm path calculation as specified in Section 11.

The format of the OSPF Flexible Algorithm Include-Any Reverse Admin Group Sub-TLV is identical to the format of the OSPF FAERAG Sub-TLV in Section 8.

IANA has assigned Type value of 11 for the OSPF Flexible Algorithm Include-Any Reverse Admin Group Sub-TLV.

The OSPF Flexible Algorithm Include-Any Reverse Admin Group Sub-TLV **MUST NOT** appear more than once in an OSPF FAD TLV. If it appears more than once, the OSPF FAD TLV **MUST** be ignored by the receiver.

10. OSPF Flexible Algorithm Include-All Reverse Admin Group Sub-TLV

The OSPF Flexible Algorithm Include-All Reverse Admin Group Sub-TLV is used to advertise the include-all rule that is used during the Flex-Algorithm path calculation as specified in Section 11.

The format of the OSPF Flexible Algorithm Include-All Reverse Admin Group Sub-TLV is identical to the format of the OSPF FAERAG Sub-TLV in Section 8.

IANA has assigned Type value of 12 for the OSPF Flexible Algorithm Include-All Reverse Admin Group Sub-TLV.

The OSPF Flexible Algorithm Include-All Reverse Admin Group Sub-TLV **MUST NOT** appear more than once in an OSPF FAD TLV. If it appears more than once, the OSPF FAD TLV **MUST** be ignored by the receiver.

11. Calculation of Flexible Algorithm Paths

The following procedures augment the rules defined in Section 13 of [RFC9350] by introducing additional constraints based on Administrative Groups (AGs) associated with the reverse direction of a link.

- Check if any exclude reverse Admin Group rule is part of the Flex-Algorithm definition. If such exclude rule exists, check if any Admin Group that is part of the exclude rule is also set on the link in the reverse direction. If such Admin Group is set on the link in the reverse direction, the link **MUST** be pruned from the computation.

- Check if any include-any reverse Admin Group rule is part of the Flex-Algorithm definition. If such include-any rule exists, check if any Admin Group that is part of the include-any rule is also set on the link in the reverse direction. If no such Admin Group is set on the link in the reverse direction, the link **MUST** be pruned from the computation.
- Check if any include-all reverse Admin Group rule is part of the Flex-Algorithm definition. If such include-all rule exists, check if all Admin Groups that are part of the include-all rule are also set on the link in the reverse direction. If all such Admin Groups are not set on the link in the reverse direction, the link **MUST** be pruned from the computation.

Please see rules 8, 9, and 10 in Section 13.3 for these added rules.

12. IGP Flex-Algorithm Path Computation Rules Registry

Since the original Flex-Algorithm specification [RFC9350], many Flex-Algorithm extensions have been proposed and standardized. Many of them added additional rules to the Flex-Algorithm path computation. Maintaining an IANA registry for these rules allows specification across multiple documents progressing independently. The new "IGP Flex-Algorithm Path Computation Rules" registry has been created and is specified in Section 13.3.

This section provides the guidance for designated experts on evaluating new registrations in the "IGP Flex-Algorithm Path Computation Rules" registry:

1. When a new constraint is defined, the rule associated with that constraint **MAY** be inserted at any position. Backwards compatibility is guaranteed because nodes that don't support the new constraint will not participate in an algorithm where the FAD specifies a constraint they don't support.
2. The relative ordering of existing rules **MUST NOT** be altered. Doing so has the potential to create backwards compatibility issues.
3. Deletion of the rules **MUST NOT** be done. Given that the rules are only used conditionally based on the information carried in the winning FAD, deletion of the rule is not necessary.
4. Merging or repeating of the rules **MUST NOT** be done.

13. IANA Considerations

13.1. Sub-Sub-TLVs for Flexible Algorithm Definition Sub-TLV

IANA has registered the following in the "IS-IS Sub-Sub-TLVs for Flexible Algorithm Definition Sub-TLV" registry under the "IS-IS TLV Codepoints" registry group:

```
Type:   10
Description:   Flexible Algorithm Exclude Reverse Admin Group
MP:   n
Reference:   RFC 9917, Section 5
```

Type: 11
Description: Flexible Algorithm Include-Any Reverse Admin Group
MP: n
Reference: RFC 9917, Section 6

Type: 12
Description: Flexible Algorithm Include-All Reverse Admin Group
MP: n
Reference: RFC 9917, Section 7

13.2. OSPF Flexible Algorithm Definition TLV Sub-TLV Registry

This document makes the following registration in the "OSPF Flexible Algorithm Definition TLV Sub-TLVs" registry under the "Open Shortest Path First (OSPF) Parameters" registry group:

Type: 10
Description: Flexible Algorithm Exclude Reverse Admin Group
Reference: RFC 9917, Section 8

Type: 11
Description: Flexible Algorithm Include-Any Reverse Admin Group
Reference: RFC 9917, Section 9

Type: 12
Description: Flexible Algorithm Include-All Reverse Admin Group
Reference: RFC 9917, Section 10

13.3. IGP Flex-Algorithm Path Computation Rules Registry

IANA has created a new registry called "IGP Flex-Algorithm Path Computation Rules" within the "Interior Gateway Protocol (IGP) Parameters" registry group. The registration procedure for the new registry is Expert Review [RFC8126]. Section 12 provides guidance for designated experts.

The "IGP Flex-Algorithm Path Computation Rules" registry specifies the ordered set of rules that are used to prune links from the topology during the Flex-Algorithm path computation.

There is no upper bound on the number of rules that the registry supports.

Sequence Number	Description	Reference
1	Check if any exclude Administrative Group rule is part of the Flex-Algorithm Definition. If such exclude rule exists, check if any color that is part of the exclude rule is also set on the link. If such a color is set, the link **MUST** be pruned from the computation	Section 13 of [RFC9350]
2	Check if any exclude SRLG rule is part of the Flex-Algorithm Definition. If such exclude rule exists, check if the link is part of any SRLG that is also part of the SRLG exclude rule. If the link is part of such SRLG, the link **MUST** be pruned from the computation.	Section 13 of [RFC9350]
3	Check if any include-any Administrative Group rule is part of the Flex-Algorithm Definition. If such include-any rule exists, check if any color that is part of the include-any rule is also set on the link. If no such color is set, the link **MUST** be pruned from the computation.	Section 13 of [RFC9350]
4	Check if any include-all Administrative Group rule is part of the Flex-Algorithm Definition. If such include-all rule exists, check if all colors that are part of the include-all rule are also set on the link. If all such colors are not set on the link, the link **MUST** be pruned from the computation.	Section 13 of [RFC9350]
5	If the Flex-Algorithm Definition uses something other than the IGP metric (Section 5 of [RFC9350]), and such metric is not advertised for the particular link in a topology for which the computation is done, such link **MUST** be pruned from the computation. A metric of value 0 **MUST NOT** be assumed in such a case.	Section 13 of [RFC9350]
6	Check if any exclude FAEMB rule is part of the Flex-Algorithm definition. If such exclude rule exists and the link has Maximum Link Bandwidth advertised, check if the link bandwidth satisfies the FAEMB rule. If the link does not satisfy the FAEMB rule, the link **MUST** be pruned from the Flex-Algorithm computation	Section 6 of [RFC9843]

Sequence Number	Description	Reference
7	Check if any exclude FAEMD rule is part of the Flex-Algorithm definition. If such exclude rule exists and the link has Min Unidirectional link delay advertised, check if the link delay satisfies the FAEMD rule. If the link does not satisfy the FAEMD rule, the link **MUST** be pruned from the Flex-Algorithm computation.	Section 6 of [RFC9843]
8	Check if any exclude reverse Admin Group rule is part of the Flex-Algorithm definition. If such exclude rule exists, check if any Admin Group that is part of the exclude rule is also set on the link in the reverse direction. If such Admin Group is set on the link in the reverse direction, the link **MUST** be pruned from the computation.	Section 11 of RFC 9917
9	Check if any include-any reverse Admin Group rule is part of the Flex-Algorithm definition. If such include-any rule exists, check if any Admin Group that is part of the include-any rule is also set on the link in the reverse direction. If no such Admin Group is set on the link in the reverse direction, the link **MUST** be pruned from the computation	Section 11 of RFC 9917
10	Check if any include-all reverse Admin Group rule is part of the Flex-Algorithm definition. If such include-all rule exists, check if all Admin Groups that are part of the include-all rule are also set on the link in the reverse direction. If all such Admin Groups are not set on the link in the reverse direction, the link **MUST** be pruned from the computation.	Section 11 of RFC 9917

Table 1: IGP Flex-Algorithm Path Calculation Rules

14. Security Considerations

This document inherits security considerations from [RFC9350].

15. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC7308] Osborne, E., "Extended Administrative Groups in MPLS Traffic Engineering (MPLS-TE)", RFC 7308, DOI 10.17487/RFC7308, July 2014, <https://www.rfc-editor.org/info/rfc7308>.

[RFC8174]   Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <https://www.rfc-editor.org/info/rfc8174>.

[RFC9350]   Psenak, P., Ed., Hegde, S., Filsfils, C., Talaulikar, K., and A. Gulko, "IGP Flexible Algorithm", RFC 9350, DOI 10.17487/RFC9350, February 2023, <https://www.rfc-editor.org/info/rfc9350>.

[RFC9843]   Hegde, S., Britto, W., Shetty, R., Decraene, B., Psenak, P., and T. Li, "IGP Flexible Algorithms: Bandwidth, Delay, Metrics, and Constraints", RFC 9843, DOI 10.17487/RFC9843, September 2025, <https://www.rfc-editor.org/info/rfc9843>.

16. Informative References

[RFC8126]   Cotton, M., Leiba, B., and T. Narten, "Guidelines for Writing an IANA Considerations Section in RFCs", BCP 26, RFC 8126, DOI 10.17487/RFC8126, June 2017, <https://www.rfc-editor.org/info/rfc8126>.

Acknowledgments

TBD

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