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IGP Unreachable Prefix Announcement

Abstract

In the presence of summarization, there is a need to signal loss of
reachability to an individual prefix covered by the summary in order
to enable fast convergence away from paths to the node which owns
the prefix which is no longer reachable.

This document describes how to use the existing protocol mechanisms
in IS-IS and OSPF, together with the two new flags, to advertise
such prefix reachability loss.

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.

Status of This Memo

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Table of Contents

1. Introduction

Link-state IGP protocols like IS-IS and OSPF are primarily used to distribute routing information between routers belonging to a single Autonomous System (AS) and to calculate the reachability for IPv4 or IPv6 prefixes advertised by the individual nodes inside the AS. Each node advertises the state of its local adjacencies, connected prefixes, capabilities, etc. The collection of these states from all the routers inside the area form a link-state database (LSDB) that describes the topology of the area and holds additional state information about the prefixes, router capabilities, etc.

The growth of networks running a link-state routing protocol results in the addition of more state which leads to scalability and convergence challenges. The organization of networks into levels/ areas and IGP domains helps limit the scope of link-state information within certain boundaries. However, the state related to prefix reachability often requires propagation across a multi-area/ level and/or multi-domain IGP network. Techniques such as summarization have been used traditionally to address the scale challenges associated with advertising prefix state outside of the local area/domain. However, this results in suppression of the individual prefix state that is useful for triggering fast-convergence mechanisms outside of the IGPs - e.g., BGP PIC Edge [I-D.ietf-rtgwg-bgp-pic].

This document defines two new flags in IS-IS and OSPF. These flags, together with the existing protocol mechanisms, provide the support for the necessary functionality. The functionality being described is called Unreachable Prefix Announcement (UPA).

Similarly, when an egress router needs to be taken out for maintenance, the traffic is drained from the node before taking it down. This is typically achieved by setting OL-bit together with using max-metric for all prefixes advertised by the node in IS-IS, or by setting max-metric on all-links and prefixes advertised by the node in OSPF. When prefixes from such node are summarized by the ABR/ASBR, nodes outside of the area or domain are unaware of such prefixes becoming unreachable. This document proposes protocol extensions to carry information about such prefixes in a backward compatible manner.

2. Supporting UPA in IS-IS

[RFC5305] defines the encoding for advertising IPv4 prefixes using 4 octets of metric information. Section 4 specifies:

"If a prefix is advertised with a metric larger then MAX_PATH_METRIC (0xFE000000, see paragraph 3.0), this prefix MUST NOT be considered

during the normal SPF computation. This allows advertisement of a
prefix for purposes other than building the normal IP routing table.
"

Similarly, [RFC5308] defines the encoding for advertising IPv6
prefixes using 4 octets of metric information. Section 2 states:

"...if a prefix is advertised with a metric larger than
MAX_V6_PATH_METRIC (0xFE000000), this prefix MUST NOT be considered
during the normal Shortest Path First (SPF) computation. This will
allow advertisement of a prefix for purposes other than building the
normal IPv6 routing table."

This functionality can be used to advertise a prefix (IPv4 or IPv6)
in a manner which indicates that reachability has been lost - and to
do so without requiring all nodes in the network to be upgraded to
support the functionality.

2.1. Advertisement of UPA in IS-IS

Existing nodes in a network that do not suport UPA will not use UPAs
during the route calculation, but will continue to flood them. This
allows flooding of such advertisements to occur without the need to
upgrade all nodes in a network.

Recognition of the advertisement as UPA is only required on routers
which have a use case for this information. Area Border Routers
(ABRs), which would be responsible for propagating UPA
advertisements into other areas would need to recognize such
advertisements.

As per the definitions referenced in the preceding section, any
prefix advertisement with a metric value greater than 0xFE000000 can
be used for purposes other than normal routing calculations. Such an
advertisement can be interpreted by the receiver as a UPA.

Optionally, an implementation may use local configuration to limit
the set of metric values which will be interpreted as UPA. The only
restriction is that such values MUST be greater than 0xFE000000.

UPA in IS-IS is supported for all IS-IS Sub-TLVs Advertising Prefix
Reachability, e.g., SRv6 Locator
[I-D.ietf-lsr-isis-srv6-extensions], Extended IP reachability
[RFC5305], MT IP Reach [RFC5120], IPv6 IP Reach [RFC5308], MT IPv6
IP Reach [RFC5120], IPv4 Algorithm Prefix Reachability TLV
[I-D.ietf-lsr-ip-flexalgo], and IPv6 Algorithm Prefix Reachability
TLV [I-D.ietf-lsr-ip-flexalgo]

2.2. Propagation of UPA in IS-IS

IS-IS allows propagation of IP prefixes in both directions between level 1 and level 2. For reachable prefixes this is only done if the prefix is reachable in source level - e.g., the prefix needs to be reachable in level 1 to be propagated to level 2 and vice verse. Such requirement of reachability MUST NOT be applied for UPAs, as they are propagating unreachability.

IS-IS L1/L2 routers may wish to advertise received UPAs into other areas (upwards and/or downwards). When propagating UPAs the original metric value MUST be preserved. The cost to reach the originator of the received UPA MUST NOT be considered when readvertising the UPA.

3. Supporting UPA in OSPF

[RFC2328] Appendix B defines the following architectural constant for OSPF:

"LSInfinity The metric value indicating that the destination described by an LSA is unreachable. Used in summary-LSAs and AS-external-LSAs as an alternative to premature aging (see Section 14.1). It is defined to be the 24-bit binary value of all ones: 0xffffff."

[RFC5340] Appendix B states:

"Architectural constants for the OSPF protocol are defined in Appendix B of OSPFV2."

indicating that these same constants are applicable to OSPFv3.

[RFC2328] section 14.1. also describes the usage of LSInfinity as a way to indicate loss of prefix reachability:

"Premature aging can also be used when, for example, one of the router's previously advertised external routes is no longer reachable. In this circumstance, the router can flush its AS-external-LSA from the routing domain via premature aging. This procedure is preferable to the alternative, which is to originate a new LSA for the destination specifying a metric of LSInfinity."

In addition, NU-bit is defined for OSPFv3 [RFC2328]. Prefixes having the NU-bit set in their PrefixOptions field should be ignored by the route calculation.

UPA in OSPFv2 is supported for OSPFv2 Summary-LSA [RFC2328], AS-external-LSAs [RFC2328], NSSA AS-external LSA.[RFC3101], and OSPFv2 Extended Prefix TLV [I-D.ietf-lsr-ip-flexalgo].

UPA in OSPFv3 is supported for Inter-Area-Prefix-LSA [RFC5340], AS-External-LSA [RFC5340], NSSA-LSA [RFC5340], E-Inter-Area-Prefix-LSA [RFC8362], E-AS-External-LSA [RFC8362], E-Type-7-LSA [RFC8362], and SRv6 Locator LSA [I-D.ietf-lsr-ospfv3-srv6-extensions].

3.1. Advertisement of UPA in OSPF

Using the existing mechanism already defined in the standards, as described in previous section, an advertisement of the inter-area or external prefix inside OSPF or OSPFv3 LSA that has the age set to value lower than MaxAge and metic set to LSInfinity can be interpreted by the receiver as a UPA.

Existing nodes in a network which receive UPA advertisements will propagate it following existing standard procedures defined by OSPF.

OSPF Area Border Routers (ABRs), which would be responsible for propagating UPA advertisements into other areas would need to recognize such advertisements.

3.2. Propagation of UPA in OSPF

Advertising prefix reachability between OSPF areas assumes prefix reachability in a source area. Such requirement of reachability MUST not be applied for UPAs, as they are propagating unreachability.

OSPF ABRs may wish to advertise received UPAs into other connected areas. When doing so, the original LSInfinity metric value in UPA MUST be preserved. The cost to reach the originator of the received UPA MUST NOT be considered when readvertising the UPA to connected areas.

4. Generation of the UPA

UPA MAY be generated by the ABR or ASBR that is performing the summarization, when all of the following conditions are met:

   - reachability of a prefix that was reachable earlier was lost

   - a summary address which covers the prefix is being advertised
     by the ABR/ASBR

Implementations are free to limit the UPA generation to specific prefixes, e.g. host prefixes, SRv6 locators, or similar. Such filtering is optional and MAY be controlled via configuration.

5. Signaling UPA

In IS-IS a prefix can be advertised with metric higher than 0xFE000000, in OSPF with metric LSInfinity, or in OSPFv3 with NU-bit

set in PrefixOptions, for various reasons. Even though in all cases
the treatment of such metric, or NU-bit, is specified for IS-IS,
OSPF and OSPFv3, having an explicit way to signal that the prefix
was advertised in order to signal unreachability is required to
distinguish it from other cases where the prefix with such metric is
advertised.

5.1. Signaling UPA in IS-IS

Two new bits in the IPv4/IPv6 Extended Reachability Attribute Flags
[RFC7794] are defined:

   U-Flag: - Unreachable Prefix Flag (Bit TBD). When set, it
   indicates that the prefix is unreachable due to the unplanned
   reason.

   UP-Flag: - Unreachable Planned Prefix Flag (Bit TBD). When set,
   it indicates that the prefix is unreachable due to the planned
   reason, e.g., planned maintenance.

The prefix that is advertised with U-Flag or UP-Flag MUST have the
metric set to a value larger than 0xFE000000. If the prefix metric
is less than or equal 0xFE000000, both of these flags MUST be
ignored.

5.2. Signaling UPA in OSPFv2

Two new bits in Flags field of the OSPFv2 Extended Prefix TLV
[RFC7684] are defined:

   U-Flag: - Unreachable Prefix Flag (Bit TBD). When set, it
   indicates that the prefix is unreachable due to the unplanned
   reason.

   UP-Flag: - Unreachable Planned Prefix Flag (Bit TBD). When set,
   it indicates that the prefix is unreachable due to the planned
   reason, e.g., planned maintenance.

   The prefix that is advertised with U-Flag or UP-Flag MUST have
   the metric set to a value LSInfinity. If the prefix metric is not
   equal to LSInfinity, both of these flags MUST be ignored. For
   default algorithm 0 prefixes with U-Flag or UP-Flag, it is
   therefore REQUIRED to advertise the unreachable prefix in the
   base OSPFv2 LSA - e.g., OSPFv2 Summary-LSA [RFC2328], or AS-
   external-LSAs [RFC2328], or NSSA AS-external LSA [RFC3101].

5.3. Signaling UPA in OSPFv3

A new Prefix Attribute Flags sub-TLV is defined as a sub-TLV of the
following OSPFv3 TLVs as defined in [RFC8362]:

```
   Intra-Area Prefix TLV

   Inter-Area Prefix TLV

   External Prefix TLV
```

   It MUST appear only once in the parent TLV 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            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Prefix Attribute Flags                     |
+-                                                            -+
|                             ...                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
where:

      Type: TBD

      Length: variable, dependent on the size of the Prefix Attribute
      Flags. MUST be a multiple of 4 octets.

      Prefix Attribute Flags: individual bits representing the flags.

   Bits in Prefix Attribute Flags are defined/sent starting with Bit 0
   defined below. Additional bit definitions that may be defined in the
   future SHOULD be assigned in ascending bit order so as to minimize
   the number of bits that will need to be transmitted.

   Undefined bits MUST be transmitted as 0 and MUST be ignored on
   receipt.

   Bits that are NOT transmitted MUST be treated as if they are set to
   0 on receipt.

   Two new bits in OSPFv3 Prefix Atribute Flags are defined:

      U-Flag: - Unreachable Prefix Flag (Bit TBD). When set, it
      indicates that the prefix became unreachable due to the unplanned
      reason.

      UP-Flag: - Unreachable Planned Prefix Flag (Bit TBD). When set,
      it indicates that the prefix became unreachable due to the
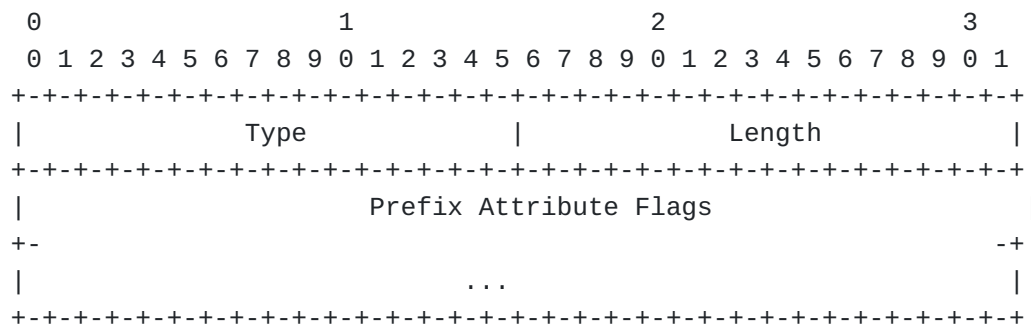   planned reason, e.g., planned maintenance.

   The prefix that is advertised with U-Flag or UP-flag MUST have the
   metric set to a value LSInfinity. For default algorithm 0 prefixes,

the LSInfinity MUST be set in the parent TLV. For IP Algorithm
Prefixes [I-D.ietf-lsr-ip-flexalgo], the LSInfinity MUST be set in
OSPFv3 IP Algorithm Prefix Reachability sub-TLV. If the prefix
metric is not equal to LSInfinity, both of these flags MUST be
ignored.

The prefix that is advertised with U-Flag or UP-Flag MUST have the
NU-bit set in the PrefixOptions of the parent TLV. If the NU-bit in
PrefixOptions of the parent TLV is not set, both of these flags MUST
be ignored.

5.4. Treatement of the U-Flag and UP-Flag

The setting of the U-Flag or the UP-Flag signals that the prefix is
unreachable. They constitute the UPA signals. Treatment of these
flags on the receiver is optional and the usage of them is outside
of scope of this document.

6. Deployment Considerations for UPA

The intent of UPA is to provide an event driven signal of the
transition of a destination from reachable to unreachable. It is not
intended to advertise a persistent state. UPA advertisements should
therefore be withdrawn after a modest amount of time, that would
provides sufficient time for UPA to be flooded network-wide and
acted upon by receiving nodes, but limits the presence of UPA in the
network to a short time period. The time the UPA is kept in the
network SHOULD also reflect the intended use-case for which the UPA
was advertised.

As UPA advertisements in IS-IS are advertised in existing Link State
PDUs (LSPs) and the unit of flooding in IS-IS is an LSP, it is
recommended that, when possible, UPAs are advertised in LSPs
dedicated to this type of advertisement. This will minimize the
number of LSPs which need to be updated when UPAs are advertised and
withdrawn.

In OSPF and OSPFv3, each inter-area and external prefix is
advertised in it's own LSA, so the above optimisation does not apply
to OSPF.

It is also recommended that implementations limit the number of UPA
advertisements which can be originated at a given time.

UPA is not meant to address an area/domain partition. When an area
partitions, while multiple ABRs advertise the same summary, each of
the ABRs can only reach portion of the summarized prefix. As a
result, depending on which ABR the traffic is using to enter a
partitioned area, the traffic could be dropped or be delivered to
its final destination. UPA does not make the problem of an area

partition any worse. In case of an area partition each of the ABRs
will generate UPAs for the destinations for which the reachability
was lost locally. As the UPA propagates to the nodes outside of a
partitioned area, it may result in such nodes picking an alternative
egress node for the traffic, if such alternate egress node exists.
If such alternate egress node resides outside of a partitioned area,
traffic will be restored. If such alternate egress node resides in a
partitioned area and is covered by the summary, the trafic will be
dropped if it enters a partitioned area via the ABR that can not
reach the alternate egress node - resulting in similar behavior as
without the UPA. Above is similarly applicable to a domain
partition.

7. Processing of the UPA

Processing of the received UPAs is optional and SHOULD be controlled
by the configuration at the receiver. The receiver itself, based on
its configuration, decides what the UPA will be used for and what
applications, if any, will be notified when UPA is received.

8. IANA Considerations

8.1. IS-IS Prefix Attribute Flags Sub-TLV

This document adds two new bits in the "IS-IS Bit Values for Prefix
Attribute Flags Sub-TLV" registry:

> Bit #: TBD
>
> Description: U-Flag
>
> Reference: This document (Section 5.1).
>
> Bit #: TDB
>
> Description: UP-Flag
>
> Reference: This document (Section 5.1).

8.2. OSPFv2 Extended Prefix TLV Flags

This document adds two new bits in the "OSPFv2 Extended Prefix TLV
Flags" registry:

Bit #: TBD

       Description: U-Flag

       Reference: This document ([Section 5.2](#)).

       Bit #: TDB

       Description: UP-Flag

       Reference: This document ([Section 5.2](#)).

8.3. OSPFv3 Extended-LSA Sub-TLVs

   This document adds new Sub-TLV in the "OSPFv3 Extended-LSA Sub-TLVs"
   registry:

       Value: TBD

       Description: Prefix Attribute Flags sub-TLV

       Reference: This document ([Section 5.3](#)).

       The L2BM column is set to X.

8.4. OSPFv3 Extended Prefix TLV Flags

   This document defines a new "OSPFv3 Extended Prefix TLV Flags"
   registry under "Open Shortest Path First v3 (OSPFv3) Parameters".

   This document adds two new bits in the newly defined "OSPFv3
   Extended Prefix TLV Flags" registry:

       Bit #: TBD

       Description: U-Flag

       Reference: This document ([Section 5.3](#)).

       Bit #: TDB

       Description: UP-Flag

       Reference: This document ([Section 5.3](#)).

9. Security Considerations

   The use of UPAs introduces the possibility that an attacker could
   inject a false, but apparently valid, UPA. However, the risk of this

occurring is no greater than the risk today of an attacker injecting any other type of false advertisement .

The risks can be reduced by the use of existing security extensions as described in [RFC5304] and [RFC5310] for IS-IS, in [RFC2328][and [RFC7474] for OSPFv2, and in [RFC5340] and [RFC4552] for OSPFv3.

10. Acknowledgements

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