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IS-IS and OSPF Extension for Event Notification
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Abstract

Link-state protocols like IS-IS and OSPF have been designed to distribute state information - state of the local adjacencies, state of the local prefix reachability, etc. Each state can have additional attributes associated with it, but all the attributes are only meaningful while the state exists.

This document extends link-state IGPs to distribute event notifications. An event notification has a very limited lifetime. It is rapidly propagated across the network and leaves no state after its lifetime.

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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[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.

Link-state protocols have been designed to distribute state information. More precisely, it's only the existent or steady state that is being advertised - local adjacencies in UP state, local prefixes that are reachable, etc. When the state does not exist anymore (e.g., adjacency transition to DOWN state), it is simply removed by the advertising node. Each state can have additional attributes associated with it, but all the attributes are only meaningful while the state exists.

There are certain types of events, that do not represent a steady state and therefore cannot be advertised, that may be useful for the network operation.

This document introduces the capability in link-state protocols to propagate event notifications that have a short and limited lifetime and do not introduce a state into IS-IS, OSPFv2, and OSPFv3. These event notifications are referred to as pulses to reflect their short-lived nature. Pulses may be used to advertise many types of events including those that are positive or negative in nature and for which there is no associated state that is to be maintained by link-state protocols.

[2.](#) Requirements for Pulse Notification

This section describes the basic requirements of the pulse based notification for link-state protocols.

Pulse Processing - processing of the pulse on the router is OPTIONAL. It's the decision of the receiver of the pulse whether the pulse is processed and any action is taken.

Reliability - the distribution of the pulses MUST be reliable.

Separation from Link-State - receiving pulses MUST NOT result in any update of the link-state topology or in any route calculation.

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Pulse advertisements MUST NOT be sent using existing protocol link-state messages.

Limited Lifetime - pulses are short-lived. There is no flushing or purging mechanism for pulses. They MUST be destroyed after their flooding procedure is complete.

Limited Retransmissions - pulses MUST be retransmitted, as required by the flooding procedure, only for a limited period.

Not Part of Database Sync - pulses MUST NOT be exchanged as part of the initial or post Graceful Restart database synchronization between adjacent peers.

Relevance to routing protocol - use of pulses is restricted to information known to the routing protocol as part of its normal operation

[3.](#) IS-IS Pulse PDUs

Two new IS-IS PDUs are introduced for pulse propagation:

Flooding Scoped Pulse LSP (FSP-LSP)

Flooding Scoped Pulse PSNP (FSP-PSNP)

[3.1.](#) IS-IS Flooding Scoped Pulse LSP

The format of an IS-IS Flooding Scoped Pulse LSP (FSP-LSP) is similar

to the format of the Flooding Scoped LSP defined in [[RFC7356](#)], with the following fields being removed:

"Reserved"

"Remaining Lifetime"

"Reserved|LSPDBOL|IS Type"

FSP-LSP supports all flooding scopes defined in [[RFC7356](#)].

An FS-Pulse-LSP has the following format:

	No. of octets
+-----+	
Intradomain Routeing	1
Protocol Discriminator	
+-----+	
Length Indicator	1
+-----+	
Version/Protocol ID	1
Extension	
+-----+	
ID Length	1
+-----+	
R R R PDU Type	1
+-----+	
Version	1
+-----+	
P Scope	1
+-----+	
PDU Length	2
+-----+	
FSP-LSP ID	ID Length + 2
+-----+	

Sequence Number		4
+-----+		
Checksum		2
+-----+		
: Variable Length Fields	:	Variable
+-----+		

PDU Type: 7 - (suggested - to be assigned by IANA)

All fields as defined in [[RFC7356](#)] for FS-LSPs

3.2. IS-IS Flooding Scoped Pulse PSNP

The format of an IS-IS Flooding Scoped Pulse PSNP (FSP-PSNP) is similar to the format of the Flooding Scoped PSNP defined in [[RFC7356](#)]

FSP-PSNP supports all flooding scopes defined in [[RFC7356](#)].

An FSP-PSNP has the following format:

	No. of octets
+-----+	
Intradomain Routeing	1
Protocol Discriminator	
+-----+	
Length Indicator	1
+-----+	
Version/Protocol ID	1
Extension	
+-----+	
ID Length	1
+-----+	
R R R PDU Type	1
+-----+	
Version	1

Reserved	1
Scope	1
PDU Length	2
Source ID	ID Length + 1
: Variable Length Fields :	Variable

PDU Type: 8 (Suggested - to be assigned by IANA) defined in [\[ISO10589\]](#).

All fields of the FSP-PSNP match the definition from Flooding Scoped PSNP in [\[RFC7356\]](#).

Variable-length fields - list of TLVs.

This document defines a new TLV to be included in FSP-PSNPs: Flooding Scope Pulse LSP Entries TLV (FSP-LSP Entries TLV) that has the following format:

	No. of octets
Type	1
Length	1
FSP-LSP ID	ID Length + 2

Sequence Number		4
+-----+		
Checksum		2
+-----+		
:	:	
+-----+		
FSP-LSP ID		ID Length + 2
+-----+		
Sequence Number		4
+-----+		
Checksum		2
+-----+		

Type: 29 (Suggested - to be assigned by IANA)

Length: (ID Length + 8) * number of entries

FSP-LSP ID: The ID of the FSP-LSP being acknowledged

Sequence Number: Sequence number of the FSP-LSP being acknowledged

Checksum: Checksum reported in the FSP-LSP

3.3. Flooding Scope Update Process Operation

The Update Process in [[IS010589](#)] is responsible for reliable flooding of LSPs. In the case of FSP-LSPs, the lack of persistence introduces some changes in how the Update Process operates.

Analogous to what is defined in [[RFC7356](#)], there is a separate instance of the Update Process for each scope supported for FSP-LSPs. The circuit(s) on which FSP-LSPs are flooded is limited to those circuits that are participating in the given scope. Consistent support of a given flooding scope on a circuit by all routers operating on that circuit is required.

FSP-LSPs are not meant to be retained beyond the minimum time needed to process the information and to provide a reasonable opportunity for flooding the information to neighbors. FSP-LSPs are also not

[[RFC8706](#)]. For this reason, an FSP Complete Sequence Number PDU is NOT REQUIRED. Flooding of an FSP-LSP on a circuit ceases after a configurable number of retries. Default number of retries is RECOMMENDED to be 3.

Receipt of an FSP-PSNP with a matching Flooding Scope Pulse LSP Entry serves as an acknowledgment of receipt of an FSP-LSP on that circuit.

FSP-LSPs SHOULD be retained in the FSP Scope Specific LSDB for ZeroAgeLifetime (60 seconds). This is done to support reliable flooding of the FSP-LSP and to minimize the possibility of reprocessing a previously received FSP-LSP.

[3.3.1.](#) FSP-LSP Generation Procedures

Although sequence numbers in FSP-LSPs are less important than in traditional LSPs since FSP-LSPs are not retained for a significant period and are not purged, they are still useful to identify a newer version of a given FSP-LSP. Nodes which originate FSP-LSPs MUST remember the last sequence number used for a given FSP-LSP and increment the sequence number when generating a new version.

FSP-LSP generation SHOULD utilize the "next" FSP-LSP ID each time new pulse information needs to be advertised i.e., if the most recent FSP-LSP ID used was A-00.n, the next set of pulse information SHOULD be advertised using FSP-LSP.ID A-00.n+1. This minimizes the possibility of confusion if other routers in the network have not yet removed A-00.n from their LSPDB.

[3.3.2.](#) FSP-LSP Acknowledgement Behavior

Determining whether a received FSP-LSP is newer than a previously received copy follows the rules defined for LSPs defined in [[ISO10589](#)].

Received FSP-LSPs which are either newer or the same as an existing entry in the LSPDB are acknowledged using FSP-PSNPs.

Received FSP-LSPs which are older than existing entries in the LSPDB are ignored. The sender of the FSP-LSP will in any case cease flooding such an FSP-LSP after a modest number of retries.

[4.](#) Use Case: Supporting BGP-PIC at scale

In this section we present one practical use case of event based notification in link-state routing protocols.

The growth of networks running a link-state routing protocol results in the addition of more state that presents itself in the form of 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 local area/domain.

However, this results in suppression of the individual prefix state that is useful for triggering fast-convergence mechanisms outside of the IGP - e.g., BGP PIC Edge [[I-D.ietf-rtgwg-bgp-pic](#)].

In such a scenario, it is desirable to enable the notification of events, such as an individual prefix becoming unreachable, outside of the local area/domain and across the network in a manner that does not leave behind any persistent state in the link-state database.

[4.1.](#) Use of Summarization

Deployment of large networks may utilize a significant number of discrete IGP areas. Advertisement of inter-area prefixes is limited to summaries to reduce the number of prefix advertisements which need to be flooded domain-wide.

Consider a network consisting of 100 areas with 1K prefixes/area. In the absence of summarization, there are 100 K prefixes which would be advertised domain-wide. If in each area there are two Area Border Routers (ABRs) - for redundancy purposes - each of which is advertising 1K intra-area prefixes into other areas, there would then be $100 \times 2 \times 1K = 200K$ prefix advertisements sent domain-wide.

If a single summary address is used to represent reachability for the 1K prefixes within an area, the number of prefix advertisements flooded domain-wide becomes $100 \times 2 \times 1 = 200$ summary prefix advertisements.

The use of summarization dramatically reduces the scale of network-wide flooding, but it also means that a change in reachability to any specific destination covered by a summary is not known to routers outside a given area.

[4.2.](#) Use of Pulse in combination w Summarization

Pulse can be used to signal loss of reachability to an individual destination covered by a summary. In the event that a single node becomes unreachable, this would result in the flooding of 2 pulses (one by each ABR in the impacted area. If we generalize this to loss of reachability to N nodes throughout the network, the total number of additional advertisements is 2N. The received pulses can then be used to trigger BGP-PIC fast convergence.

The economy provided by the use of pulses in this use case diminishes linearly with the number of nodes which fail within a given time interval. In the event of a catastrophic network failure where many nodes fail within a given pulse interval, the number of pulses present in the network could begin to approach the number of individual prefixes present in the domain - which would effectively eliminate the scale benefits of the summary. Therefore, when using pulse for this use case, implementations SHOULD limit the number of pulses which are advertised in a given time interval.

[4.3.](#) IS-IS Summary Component Reachability Loss Pulse TLV

IS-IS Summary Component Reachability Loss Pulse (SCRLP) TLV MAY be sent in an FSP-LSP. It is used by the IS-IS L1/L2 routers or by IS-IS Autonomous Boundary Routers (ASBR) that are performing prefix summarization at the area or domain boundary, to inform other nodes in the attached area(s) or domain(s) about the loss of the reachability to a previously reachable component of the summary-prefix inside the area or domain from which the summary-prefix is originated.

The IS-IS SCRLP TLV has the following format:

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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	2	3	4	5	6	7	8	9
Type										Length										Flags																			
R R R R										MT ID																													
S Summ-Pfx Len																																							
Summary Prefix (variable) ...																																							
Sub-TLV-len										Sub-TLVs (variable) . . .																													
S Comp-Pfx Len																																							
Component Prefix (variable) ...																																							
Sub-TLV-len										Sub-TLVs (variable) . . .																													
S Comp-Pfx Len																																							
Component Prefix (variable) ...																																							
Sub-TLV-len										Sub-TLVs (variable) . . .																													
										...																													

where:

Type: 1

Length: variable

Flags: 1 octet. The following flags are defined:

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

D-flag: Same as described in [section 4.1. of \[RFC5305\]](#).

F-flag: If unset, then the Summary Prefix and Component Prefix(es) are IPv4 prefixes. If set, then the Summary Prefix and Component Prefix(es) are IPv6 prefixes.

The remaining bits are reserved for future use. They MUST be set to zero on transmission and MUST be ignored on receipt.

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

MT ID: Multitopology Identifier as defined in [\[RFC5120\]](#). Note that the value 0 is legal.

Summ-Pfx Length + Flag: 1 octet

Summ-Pfx Length: Length of the Summary Prefix in bits. Valid values are (0-31) when F-flag is unset, (0-127) when F-flag is set.

S-bit: MUST be set when Sub-TLVs are present for Summary Prefix, otherwise MUST NOT be set.

Summary Prefix: variable. IPv4 or IPv6 Summary Prefix.

Sub-TLV-length: 1 octet. Number of octets used by Summary Prefix Sub-TLVs. Only present when S-bit is set.

Optional Sub-TLVs: No Sub-TLVs are defined by this document.

Comp-Pfx Length + Flag: 1 octet

Comp-Pfx Len.: 1 octet. Length of the Component Prefix in bits. Valid values are (1-32) when F-flag is unset, (1-128) when F-flag is set. Comp-Pfx Len MUST be > Summ-Pfx Length.

S-bit: MUST be set when Sub-TLVs are present for Component Prefix, otherwise MUST NOT be set.

Component Prefix: variable. IPv4 or IPv6 Component Prefix.

Sub-TLV-length: 1 octet. Number of octets used by Component Prefix sub-TLVs. Only present when S-bit is set.

Optional sub-TLVs: No Sub-TLVs are defined by this document.

When an IS-IS L1/L2 router or an IS-IS Autonomous Boundary Router (ASBR) is performing prefix summarization and it loses the reachability to one or more previously reachable component(s) of the summary-prefix inside the area or domain for which the summarization is done, it MAY originate the SCRLP TLV to inform routers in other areas or domains about such summary component-prefix reachability loss.

An originator of the SCRLP TLV chooses to advertise it in FSP-LSP with L1 flooding scope and/or FSP-LSP with L2 flooding scope.

The IS-IS SCRLP TLV MAY be leaked between levels on L1/L2 router, subject to local policy of such L1/L2 router.

IS-IS SCRLP TLV MUST NOT be leaked inside the area if the summary prefix carried in IS-IS SCRLP TLV (Summary Prefix, Summ-Pfx Length) is advertised from such area by L1/L2 router.

When the router receives the SCRLP TLV it MAY choose to inform the BGP component on the router. BGP component on the router MAY trigger BGP Prefix Independent Convergence (PIC) as specified in [\[I-D.ietf-rtgwg-bgp-pic\]](#) as a result of such notification.

The mechanism on how the IS-IS passes the information from IS-IS SCRLP TLV to the BGP component or how the BGP component uses this information to trigger the PIC is implementation-specific and outside

of the scope of this specification.

The IS-IS SCRLP TLV may be used by other applications on the receiving node that wish to be notified about the loss of summary component-prefix reachability. The details of such usage are outside of the scope of this specification.

[5.](#) Handling of the Control Plane Restart and ISSU

An egress PE may undergo a control-plane or protocol restart, or and In-Service Software Upgrade. If these events are performed using Nonstop Forwarding (NSF) as specified in [[RFC3847](#)] or Nonstop Routing (NSR) procedures, the egress PE reachability inside its area is preserved and no Pulse would be generated as a result of these events.

If the IS-IS protocol restart, or route-processor fail-over on the egress PE is performed using cold-restart procedures, the egress PE reachability will be lost and Pulse will be generated by the ABRs connected to the area. This is an expected behavior, as in case of the cold-restart recovery the traffic is expected to be dropped if forwarded to the egress PE and using an alternate BGP path is desirable.

[6.](#) OSPF Pulse Notification

TBD.

[7.](#) OSPFv3 Pulse Notification

TBD.

[8.](#) IANA Considerations

[8.1.](#) New IS-IS PDU Types

This document includes the definition of two new PDU types that are reflected in the "IS-IS PDU Registry":

Value	Description
7	FSP-LSP
8	FSP-PSNP

8.2. Revised sub-TLV table

IANA is requested to modify the table in "TLV Codepoints Registry" by adding columns for FSP-LSP and FSP-PSNP and set FSP-LSP:n and FSP-PSNP:n for all existing TLVs with the exception of 10 (Authentication) and 11 (ESN).

8.3. IS-IS Flooding Scope Pulse LSP Entries TLV

This document makes the following registrations in the IS-IS TLV Codepoints registry:

Type	Description	IIH	LSP	SNP	Purge	FSP-LSP	FSP-PSNP
29	FS-LSP Entries TLV	n	n	n	n	n	y

8.4. IS-IS Summary Component Reachability Loss Pulse TLV

This document makes the following registrations in the IS-IS TLV Codepoints registry:

Type	Description	IIH	LSP	SNP	Purge	FSP-LSP	FSP-PSNP
30	Summary Component Reachability Loss Pulse	n	n	n	n	y	n

9. Security Considerations for ISIS

The introduction of new PDU types introduces the possibility that an attacker could inject a false but apparently valid PDU. The use of

cryptographic authentication as defined in [[RFC5304](#)] or [[RFC5310](#)] minimizes the possibility of such occurrences.

Replay attacks could still be possible. Prevention of replay attacks

can be done by including the Extended Sequence Numbers(ESN) TLV [RFC7602] in FSP-LSPs and FSP-PSNPs. Note, however, that the use of ESN MUST be done independently for each FSP-LSP ID. It is not safe to use a single ESN for the FSP-LSP PDU Type (as is done with hellos and SNPs) since we cannot guarantee the order in which multiple FSP-LSPs from the same source may arrive at a given node.

If a false PDU were to be injected, invalid SCRLP information could falsely trigger BGP-PIC behavior.

10. Security Considerations for OSPF

TBD.

11. Contributors

TBD

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12.1. Normative References

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[12.2.](#) Informative References

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[Appendix A.](#) BGP Pulse Handling

Handling of the Pulse by the receiving application is out of scope of this document. This section provides some informational, high-level description on how a BGP on an ingress PE (Provider Edge) device may use the Pulse to trigger the BGP PIC (Prefix Independent Convergence). Note that PIC is a local behavior on ingress PE, which is implementation specific and nothing in this section mandates the implementation to follow what is described here to any degree.

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Assuming the BGP multi-path destination prefix on an ingress PE, the arrival of the Pulse, that indicates the loss of reachability of the BGP next-hop for the primary path, can trigger the BGP PIC for such prefix. This is similar in nature to what happens on ingress PE without the use of summarization when the BGP next-hop for primary path becomes unreachable.

In case the egress PE associated with the primary BGP path went down, BGP on the ingress PE would eventually receive a withdrawal of such path and would re-converge to the alternate path out of multi-paths. Note that this happens independently of and after the BGP PIC was triggered previously.

If the loss of reachability signaled by the Pulse is short-lived, it is desirable that BGP reconverge to the state prior to receipt of the Pulse. However, determination of the transient nature of the loss of reachability depends on the absence of BGP updates which would be expected following the loss of reachability to the egress PE. This can be determined by triggering a timer on receipt of the Pulse. If that timer expires without receipt of the expected BGP updates, then BGP can reconverge to the pre-pulse state. The timer duration needs to be long enough to allow for the expected BGP convergence to take place in the case where the loss of reachability to the egress PE is not transient.

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