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Micro-loop prevention by introducing a local convergence delay
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Abstract

This document describes a mechanism for link-state routing protocols to prevent local transient forwarding loops in case of link failure. This mechanism proposes a two-step convergence by introducing a delay between the convergence of the node adjacent to the topology change and the network wide convergence.

As this mechanism delays the IGP convergence it may only be used for planned maintenance or when fast reroute protects the traffic between the link failure time and the IGP convergence.

The proposed mechanism is limited to the link down event in order to keep the mechanism simple.

Simulations using real network topologies have been performed and show that local loops are a significant portion (>50%) of the total forwarding loops.

Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on May 16, 2018.

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1. Acronyms

FIB: Forwarding Information Base

FRR: Fast ReRoute

IGP: Interior Gateway Protocol

LFA: Loop Free Alternate

LSA: Link State Advertisement

LSP: Link State Packet

MRT: Maximum Redundant Trees

OFIB: Ordered FIB

PLSN: Path Locking via Safe Neighbor

RIB: Routing Information Base

RLFA: Remote Loop Free Alternate

SPF: Shortest Path First

TTL: Time To Live

2. Introduction

Micro-forwarding loops and some potential solutions are well described in [RFC5715]. This document describes a simple targeted mechanism that prevents micro-loops that are local to the failure. Based on network analysis, local failures make up a significant portion of the micro-forwarding loops. A simple and easily deployable solution for these local micro-loops is critical because these local loops cause some traffic loss after a fast-reroute alternate has been used (see Section 3.1).

Consider the case in Figure 1 where S does not have an LFA (Loop Free Alternate) to protect its traffic to D when the S-D link fails. That means that all non-D neighbors of S on the topology will send to S any traffic destined to D; if a neighbor did not, then that neighbor would be loop-free. Regardless of the advanced fast-reroute (FRR) technique used, when S converges to the new topology, it will send its traffic to a neighbor that was not loop-free and thus cause a local micro-loop. The deployment of advanced fast-reroute techniques motivates this simple router-local mechanism to solve this targeted problem. This solution can work with the various techniques described in [RFC5715].

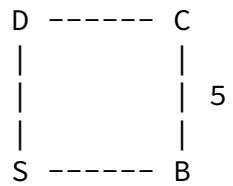


Figure 1

In the Figure 1, all links have a metric of 1 except B-C which has a metric of 5. When S-D fails, a transient forwarding loop may appear between S and B if S updates its forwarding entry to D before B does.

3. Transient forwarding loops side effects

Even if they are very limited in duration, transient forwarding loops may cause significant network damage.

3.1. Fast reroute inefficiency

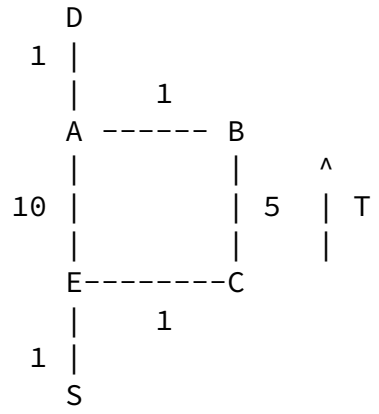


Figure 2 - RSVP-TE FRR case

In the Figure 2, we consider an IP/LDP routed network. An RSVP-TE tunnel T, provisioned on C and terminating on B, is used to protect

the traffic against C-B link failure (the IGP shortcut feature, defined in [RFC3906], is activated on C). The primary path of T is C->B and FRR is activated on T providing an FRR bypass or detour using path C->E->A->B. On router C, the next hop to D is the tunnel T thanks to the IGP shortcut. When C-B link fails:

1. C detects the failure, and updates the tunnel path using a preprogrammed FRR path. The traffic path from S to D becomes: S->E->C->E->A->B->A->D.

2. In parallel, on router C, both the IGP convergence and the TE tunnel convergence (tunnel path recomputation) are occurring:

   * The Tunnel T path is recomputed and now uses C->E->A->B.

   * The IGP path to D is recomputed and now uses C->E->A->D.

3. On C, the tail-end of the TE tunnel (router B) is no longer on the shortest-path tree (SPT) to D, so C does not continue to encapsulate the traffic to D using the tunnel T and updates its forwarding entry to D using the nexthop E.

If C updates its forwarding entry to D before router E, there would be a transient forwarding loop between C and E until E has converged.

The table 1 below describes a theoretical sequence of events happening when the B-C link fails. This theoretical sequence of events should only be read as an example.

Network condition	Time	Router C events	Router E events
S->D Traffic OK			
S->D Traffic lost	t0	Link B-C fails	Link B-C fails
	t0+20msec	C detects the failure	
S->D Traffic OK	t0+40msec	C activates FRR	
	t0+50msec	C updates its local LSP/LSA	
	t0+60msec	C schedules SPF (100ms)	
	t0+70msec	C floods its local updated LSP/LSA	
	t0+87msec		E receives LSP/LSA from C and schedules SPF (100ms)
	t0+117msec		E floods LSP/LSA from

			C
	t0+160msec	C computes SPF	
	t0+165msec	C starts updating its RIB/FIB	
	t0+193msec		E computes SPF
	t0+199msec		E starts updating its RIB/FIB
S->D Traffic lost	t0+255msec	C updates its RIB/FIB for D	
	t0+340msec	C convergence ends	
S->D Traffic OK	t0+443msec		E updates its RIB/FIB for D
	t0+470msec		E convergence ends

Table 1 - Route computation event time scale

The issue described here is completely independent of the fast-reroute mechanism involved (TE FRR, LFA/rLFA, MRT ...) when the primary path uses hop-by-hop routing. The protection enabled by fast-reroute is working perfectly, but ensures a protection, by

definition, only until the PLR has converged (as soon as the PLR has converged, it replaces its FRR path by a new primary path). When implementing FRR, a service provider wants to guarantee a very limited loss of connectivity time. The previous example shows that the benefit of FRR may be completely lost due to a transient forwarding loop appearing when PLR has converged. Delaying FIB updates after the IGP convergence may allow to keep the fast-reroute path until the neighbors have converged and preserves the customer

traffic.

3.2. Network congestion

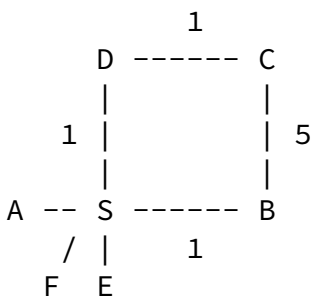


Figure 3

In the figure above, as presented in Section 2, when the link S-D fails, a transient forwarding loop may appear between S and B for destination D. The traffic on the S-B link will constantly increase due to the looping traffic to D. Depending on the TTL of the packets, the traffic rate destined to D, and the bandwidth of the link, the S-B link may become congested in a few hundreds of milliseconds and will stay congested until the loop is eliminated.

The congestion introduced by transient forwarding loops is problematic as it can affect traffic that is not directly affected by the failing network component. In the example, the congestion of the S-B link will impact some customer traffic that is not directly affected by the failure: e.g. A to B, F to B, E to B. Class of service may mitigate the congestion for some traffic. However, some traffic not directly affected by the failure will still be dropped as a router is not able to distinguish the looping traffic from the normally forwarded traffic.

4. Overview of the solution

This document defines a two-step convergence initiated by the router detecting a failure and advertising the topological changes in the IGP. This introduces a delay between network-wide convergence and the convergence of the local router.

The proposed solution is limited to local link down events in order

to keep the solution simple.

This ordered convergence is similar to the ordered FIB proposed defined in [RFC6976], but it is limited to only a "one hop" distance. As a consequence, it is more simple and becomes a local-only feature that does not require interoperability. This benefit comes with the limitation of eliminating transient forwarding loops involving the local router only. The proposed mechanism also reuses some concepts described in [I-D.ietf-rtgwg-microloop-analysis].

5. Specification

5.1. Definitions

This document will refer to the following existing IGP timers. These timers may be standardized or implemented as a vendor specific local feature.

- LSP_GEN_TIMER: The delay between two consecutives local LSP/LSA generation. From an operational point of view, this delay is usually tuned to batch multiple local events in one single local LSP/LSA update. In IS-IS, this timer is defined as minimumLSPGenerationInterval in [ISO10589]. In OSPF version 2, this timer is defined as MinLSInterval in [RFC2328]. It is often associated with a vendor specific damping mechanism to slow down reactions by incrementing the timer when multiple consecutive events are detected.

- SPF_DELAY: The delay between the first IGP event triggering a new routing table computation and the start of that routing table computation. It is often associated with a damping mechanism to slow down reactions by incrementing the timer when the IGP becomes unstable. As an example, [I-D.ietf-rtgwg-backoff-algo] defines a standard SPF (Shortest Path First) delay algorithm.

This document introduces the following new timer:

- ULOOP_DELAY_DOWN_TIMER: used to slow down the local node convergence in case of link down events.

5.2. Regular IGP reaction

Upon a change of the status of an adjacency/link, the regular IGP convergence behavior of the router advertising the event involves the following main steps:

1. IGP is notified of the Up/Down event.

2. The IGP processes the notification and postpones the reaction for LSP_GEN_TIMER msec.

3. Upon LSP_GEN_TIMER expiration, the IGP updates its LSP/LSA and floods it.

4. The SPF computation is scheduled in SPF_DELAY msec.

5. Upon SPF_DELAY timer expiration, the SPF is computed, then the RIB and FIB are updated.

5.3. Local events

The mechanism described in this document assumes that there has been a single link failure as seen by the IGP area/level. If this assumption is violated (e.g. multiple links or nodes failed), then regular IP convergence must be applied (as described in Section 5.2).

To determine if the mechanism can be applicable or not, an implementation SHOULD implement logic to correlate the protocol messages (LSP/LSA) received during the SPF scheduling period in order to determine the topology changes that occured. This is necessary as multiple protocol messages may describe the same topology change and a single protocol message may describe multiple topology changes. As a consequence, determining a particular topology change MUST be independent of the order of reception of those protocol messages. How the logic works is left to the implementation.

Using this logic, if an implementation determines that the associated topology change is a single local link failure, then the router MAY use the mechanism described in this document, otherwise the regular IP convergence MUST be used.

Example:

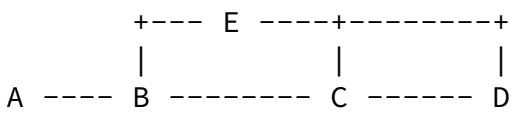


Figure 4

Let router B be the computing router when the link B-C fails. B updates its local LSP/LSA describing the link B->C as down, C does the same, and both start flooding their updated LSP/LSAs. During the SPF_DELAY period, B and C learn all the LSPs/LSAs to consider. B sees that C is flooding an advertisement that indicates that a link

is down, and B is the other end of that link. B determines that B and C are describing the same single event. Since B receives no

other changes, B can determine that this is a local link failure and may decide to activate the mechanism described in this document.

5.4. Local delay for link down

Upon an adjacency/link down event, this document introduces a change in step 5 (Section 5.2) in order to delay the local convergence compared to the network wide convergence. The new step 5 is described below:

> 5. Upon SPF_DELAY timer expiration, the SPF is computed. If the condition of a single local link-down event has been met, then an update of the RIB and the FIB MUST be delayed for ULOOP_DELAY_DOWN_TIMER msecs. Otherwise, the RIB and FIB SHOULD be updated immediately.

If a new convergence occurs while ULOOP_DELAY_DOWN_TIMER is running, ULOOP_DELAY_DOWN_TIMER is stopped and the RIB/FIB SHOULD be updated as part of the new convergence event.

As a result of this addition, routers local to the failure will converge slower than remote routers. Hence it SHOULD only be done for a non-urgent convergence, such as for administrative de-activation (maintenance) or when the traffic is protected by fast-reroute.

6. Applicability

As previously stated, this mechanism only avoids the forwarding loops on the links between the node local to the failure and its neighbors. Forwarding loops may still occur on other links.

6.1. Applicable case: local loops

Figure 5

Let us consider the traffic from G to F. The primary path is G->D->C->E->F. When link C-E fails, if C updates its forwarding entry for F before D, a transient loop occurs. This is sub-optimal as C has FRR enabled and it breaks the FRR forwarding while all upstream routers are still forwarding the traffic to itself.

By implementing the mechanism defined in this document on C, when the C-E link fails, C delays the update of its forwarding entry to F, in order to allow some time for D to converge. FRR on C keeps protecting the traffic during this period. When the timer expires on C, its forwarding entry to F is updated. There is no transient forwarding loop on the link C-D.

6.2. Non applicable case: remote loops

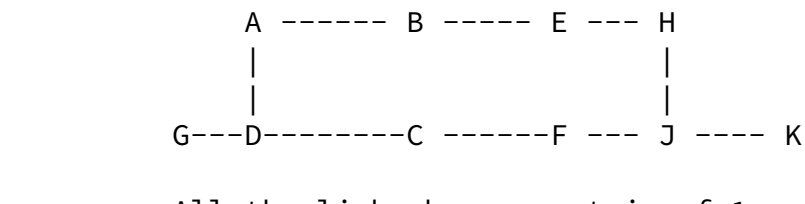


Figure 6

Let us consider the traffic from G to K. The primary path is G->D->C->F->J->K. When the C-F link fails, if C updates its forwarding entry to K before D, a transient loop occurs between C and D.

By implementing the mechanism defined in this document on C, when the link C-F fails, C delays the update of its forwarding entry to K, allowing time for D to converge. When the timer expires on C, its forwarding entry to F is updated. There is no transient forwarding loop between C and D. However, a transient forwarding loop may still occur between D and A. In this scenario, this mechanism is not enough to address all the possible forwarding loops. However, it does not create additional traffic loss. Besides, in some cases -such as when the nodes update their FIB in the following order C, A,

D, for example because the router A is quicker than D to converge- the mechanism may still avoid the forwarding loop that would have otherwise occurred.

7. Simulations

Simulations have been run on multiple service provider topologies.

Topology	Gain
T1	71%
T2	81%
T3	62%
T4	50%
T5	70%
T6	70%
T7	59%
T8	77%

Table 2 - Number of Repair/Dst that may loop

We evaluated the efficiency of the mechanism on eight different service provider topologies (different network size, design). The benefit is displayed in the table above. The benefit is evaluated as follows:

- We consider a tuple (link A-B, destination D, PLR S, backup nexthop N) as a loop if upon link A-B failure, the flow from a router S upstream from A (A could be considered as PLR also) to D may loop due to convergence time difference between S and one of his neighbors N.

- We evaluate the number of potential loop tuples in normal conditions.

- We evaluate the number of potential loop tuples using the same topological input but taking into account that S converges after N.

- The gain is how many loops (both remote and local) we succeed to suppress.

On topology 1, 71% of the transient forwarding loops created by the failure of any link are prevented by implementing the local delay. The analysis shows that all local loops are prevented and only remote loops remain.

8. Deployment considerations

Transient forwarding loops have the following drawbacks:

- They limit FRR efficiency: even if FRR is activated within 50msec, as soon as PLR has converged, the traffic may be affected by a transient loop.

- They may impact traffic not directly affected by the failure (due to link congestion).

This local delay proposal is a transient forwarding loop avoidance mechanism (like OFIB). Even if it only addresses local transient loops, the efficiency versus complexity comparison of the mechanism makes it a good solution. It is also incrementally deployable with incremental benefits, which makes it an attractive option both for vendors to implement and service providers to deploy. Delaying the convergence time is not an issue if we consider that the traffic is protected during the convergence.

The ULOOP_DELAY_DOWN_TIMER value should be set according to the maximum IGP convergence time observed in the network (usually observed in the slowest node).

The proposed mechanism is limited to link down events. When a link goes down, it eventually goes back up. As a consequence, with the

proposed mechanism deployed, only the link down event will be protected against transient forwarding loops while the link up event will not. If the operator wants to limit the impact of the transient forwarding loops during the link up event, it should take care of using specific procedures to bring the link back online. As examples, the operator can decide to put back the link online out of business hours or it can use some incremental metric changes to prevent loops (as proposed in [RFC5715]).

9. Examples

We will consider the following figure for the associated examples :

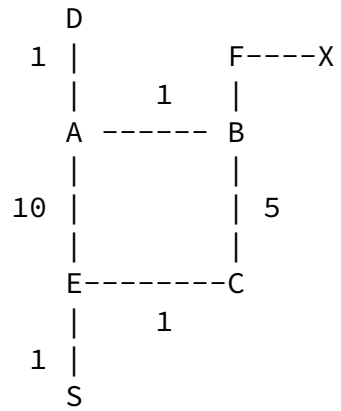
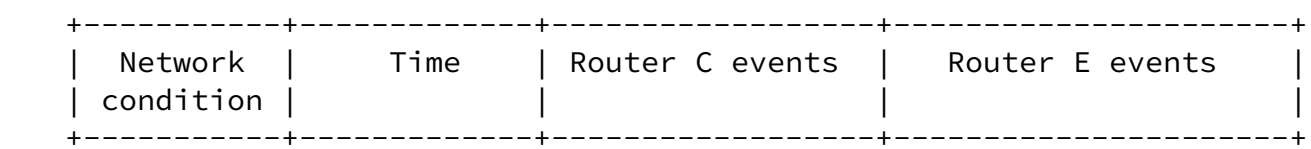


Figure 7

The network above is considered to have a convergence time about 1 second, so ULOOP_DELAY_DOWN_TIMER will be adjusted to this value. We also consider that FRR is running on each node.

9.1. Local link down

The table 3 describes the events and associated timing that happen on router C and E when link B-C goes down. It is based on a theoretical sequence of event that should only been read as an example. As C detects a single local event corresponding to a link down (its LSP + LSP from B received), it applies the local delay down behavior and no microloop is formed.


| Network condition | Time | Router C events | Router E events |

S->D Traffic OK				
S->D Traffic lost	t0	Link B-C fails	Link B-C fails	
	t0+20msec	C detects the failure		
S->D Traffic OK	t0+40msec	C activates FRR		
	t0+50msec	C updates its local LSP/LSA		
	t0+60msec	C schedules SPF (100ms)		
	t0+67msec	C receives LSP/LSA from B		
	t0+70msec	C floods its local updated LSP/LSA		
	t0+87msec		E receives LSP/LSA from C and schedules SPF (100ms)	
	t0+117msec		E floods LSP/LSA from C	
	t0+160msec	C computes SPF		
	t0+165msec	C delays its RIB/FIB update (1 sec)		
	t0+193msec		E computes SPF	
	t0+199msec		E starts updating	

			its RIB/FIB
	t0+443msec		E updates its RIB/FIB for D
	t0+470msec		E convergence ends
	t0+1165msec	C starts updating its RIB/FIB	
	t0+1255msec	C updates its RIB/FIB for D	
	t0+1340msec	C convergence ends	

Table 3 - Route computation event time scale

Similarly, upon B-C link down event, if LSP/LSA from B is received before C detects the link failure, C will apply the route update delay if the local detection is part of the same SPF run. The table 4 describes the associated theoretical sequence of events. It should only been read as an example.

Network condition	Time	Router C events	Router E events
S->D Traffic OK			
S->D Traffic lost	t0	Link B-C fails	Link B-C fails
	t0+32msec	C receives LSP/LSA from B	
	t0+33msec	C schedules SPF (100ms)	
	t0+50msec	C detects the failure	

| S->D | t0+55msec | C activates FRR | |

Traffic OK			
	t0+55msec	C updates its local LSP/LSA	
	t0+70msec	C floods its local updated LSP/LSA	
	t0+87msec		E receives LSP/LSA from C and schedules SPF (100ms)
	t0+117msec		E floods LSP/LSA from C
	t0+160msec	C computes SPF	
	t0+165msec	C delays its RIB/FIB update (1 sec)	
	t0+193msec		E computes SPF
	t0+199msec		E starts updating its RIB/FIB
	t0+443msec		E updates its RIB/FIB for D
	t0+470msec		E convergence ends
	t0+1165msec	C starts updating its RIB/FIB	
	t0+1255msec	C updates its RIB/FIB for D	

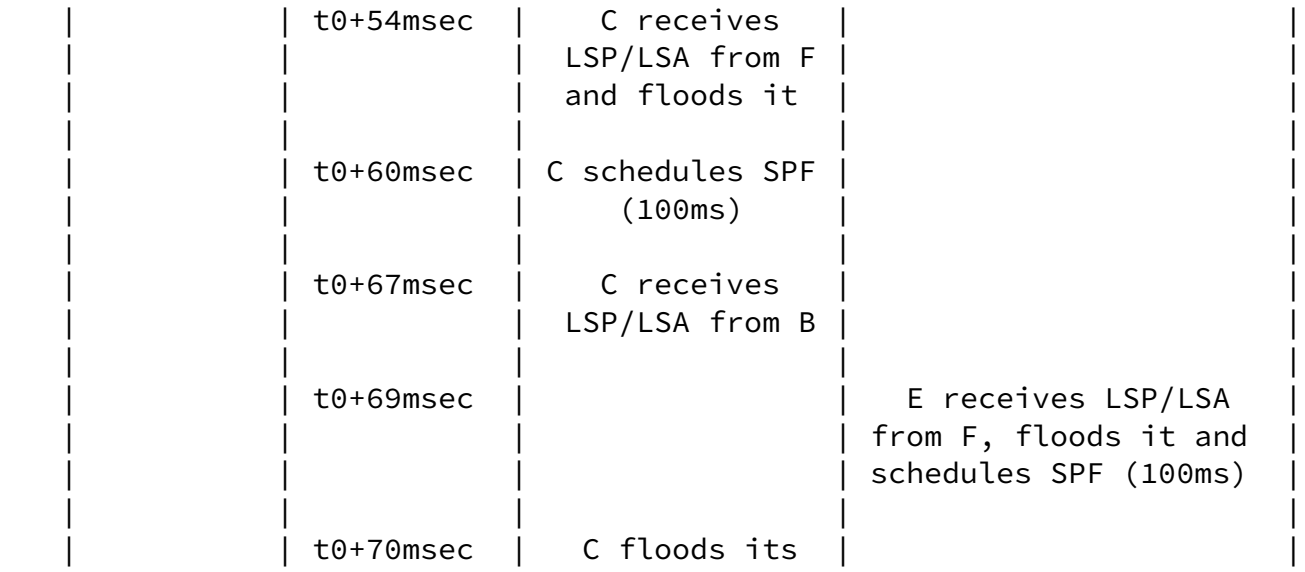
	t0+1340msec	C convergence ends	

Table 4 - Route computation event time scale

9.2. Local and remote event

The table 5 describes the events and associated timing that happen on router C and E when link B-C goes down, in addition F-X link will fail in the same time window. C will not apply the local delay because a non local topology change is also received. The table 5 is based on a theoretical sequence of event that should only been read as an example.

Network condition	Time	Router C events	Router E events
S->D Traffic OK			
S->D Traffic lost	t0	Link B-C fails	Link B-C fails
	t0+20msec	C detects the failure	
	t0+36msec	Link F-X fails	Link F-X fails
S->D Traffic OK	t0+40msec	C activates FRR	
	t0+50msec	C updates its local LSP/LSA	


t0+54msec
C receives LSP/LSA from F and floods it
t0+60msec
C schedules SPF (100ms)
t0+67msec
C receives LSP/LSA from B
t0+69msec
E receives LSP/LSA from F, floods it and schedules SPF (100ms)
t0+70msec
C floods its local updated LSP/LSA
t0+87msec
E receives LSP/LSA from C
t0+117msec
E floods LSP/LSA from C
t0+160msec
C computes SPF
t0+165msec
C starts updating its RIB/FIB (NO DELAY)
t0+170msec
E computes SPF
t0+173msec
E starts updating its RIB/FIB
S->D Traffic lost
t0+365msec
C updates its RIB/FIB for D
S->D
t0+443msec
E updates its RIB/FIB

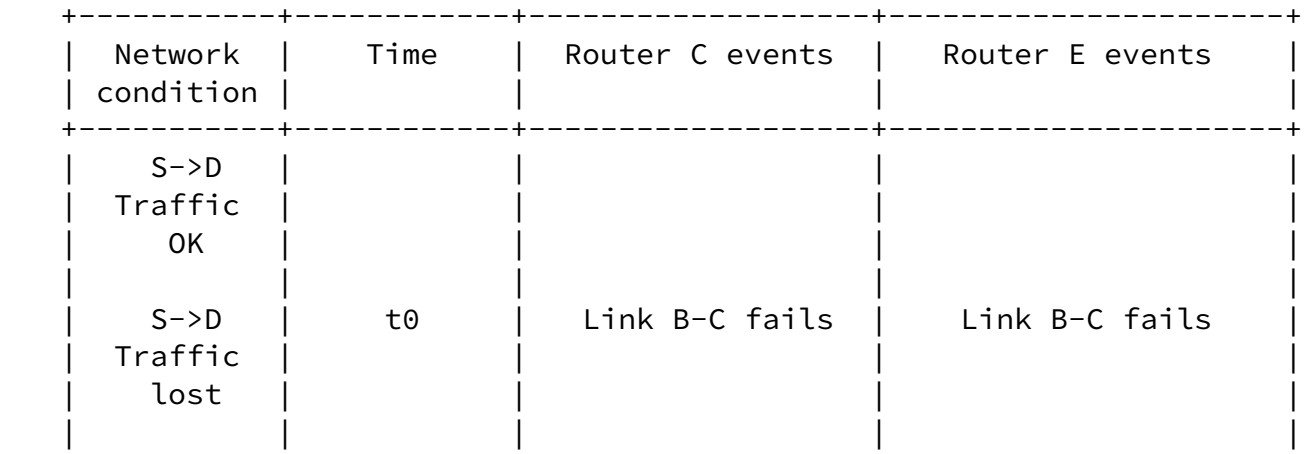
Traffic OK				for D
	t0+450msec	C convergence ends		
	t0+470msec			E convergence ends

Table 5 - Route computation event time scale

9.3. Aborting local delay

The table 6 describes the events and associated timing that happen on router C and E when link B-C goes down. In addition, we consider what happens when F-X link fails during local delay of the FIB update. C will first apply the local delay, but when the new event happens, it will fall back to the standard convergence mechanism without further delaying route insertion. In this example, we consider a ULOOP_DELAY_DOWN_TIMER configured to 2 seconds. The table

6 is based on a theoretical sequence of event that should only been read as an example.


Network condition
Time
Router C events
Router E events
S->D Traffic OK
t0
Link B-C fails
Link B-C fails
S->D Traffic lost

	t0+20msec	C detects the failure		
S->D Traffic OK	t0+40msec	C activates FRR		
	t0+50msec	C updates its local LSP/LSA		
	t0+60msec	C schedules SPF (100ms)		
	t0+67msec	C receives LSP/LSA from B		
	t0+70msec	C floods its local updated LSP/LSA		
	t0+87msec		E receives LSP/LSA from C and schedules SPF (100ms)	
	t0+117msec		E floods LSP/LSA from C	
	t0+160msec	C computes SPF		
	t0+165msec	C delays its RIB/FIB update (2 sec)		
	t0+193msec		E computes SPF	
	t0+199msec		E starts updating its RIB/FIB	
	t0+254msec	Link F-X fails	Link F-X fails	
	t0+300msec	C receives		

		LSP/LSA from F and floods it	
	t0+303msec	C schedules SPF (200ms)	
	t0+312msec	E receives LSP/LSA from F and floods it	
	t0+313msec	E schedules SPF (200ms)	
	t0+502msec	C computes SPF	
	t0+505msec	C starts updating its RIB/FIB (NO DELAY)	
	t0+514msec		E computes SPF
	t0+519msec		E starts updating its RIB/FIB
S->D Traffic lost	t0+659msec	C updates its RIB/FIB for D	
S->D Traffic OK	t0+778msec		E updates its RIB/FIB for D
	t0+781msec	C convergence ends	
	t0+810msec		E convergence ends

Table 6 - Route computation event time scale

10. Comparison with other solutions

As stated in Section 4, the proposed solution reuses some concepts already introduced by other IETF proposals but tries to find a tradeoff between efficiency and simplicity. This section tries to compare behaviors of the solutions.

10.1. PLSN

PLSN ([I-D.ietf-rtgwg-microloop-analysis]) describes a mechanism where each node in the network tries to avoid transient forwarding loops upon a topology change by always keeping traffic on a loop-free path for a defined duration (locked path to a safe neighbor). The locked path may be the new primary nexthop, another neighbor, or the old primary nexthop depending how the safety condition is satisfied.

PLSN does not solve all transient forwarding loops (see [I-D.ietf-rtgwg-microloop-analysis] Section 4 for more details).

Our solution reuses some concept of PLSN but in a more simple fashion:

- PLSN has three different behaviors: keep using old nexthop, use new primary nexthop if it is safe, or use another safe nexthop, while the proposed solution only has one: keep using the current nexthop (old primary, or already activated FRR path).

- PLSN may cause some damage while using a safe nexthop which is not the new primary nexthop in case the new safe nexthop does not provide enough bandwidth (see [RFC7916]). This solution may not experience this issue as the service provider may have control on the FRR path being used preventing network congestion.

- PLSN applies to all nodes in a network (remote or local changes), while the proposed mechanism applies only on the nodes connected to the topology change.

10.2. OFIB

OFIB ([RFC6976]) describes a mechanism where the convergence of the network upon a topology change is ordered in order to prevent transient forwarding loops. Each router in the network must deduce the failure type from the LSA/LSP received and computes/applies a specific FIB update timer based on the failure type and its rank in the network considering the failure point as root.

This mechanism allows to solve all the transient forwarding loop in a network at the price of introducing complexity in the convergence process that may require a strong monitoring by the service provider.

Our solution reuses the OFIB concept but limits it to the first hop that experiences the topology change. As demonstrated, the mechanism proposed in this document allows to solve all the local transient forwarding loops that represents an high percentage of all the loops. Moreover limiting the mechanism to one hop allows to keep the network-wide convergence behavior.

11. Implementation Status

At this time, there are three different implementations of this mechanism.

- Implementation 1:
  - Organization: Cisco
  - Implementation name: Local Microloop Protection
  - Operating system: IOS-XE
  - Level of maturity: production release
  - Coverage: all the specification is implemented
  - Protocols supported: ISIS and OSPF
  - Implementation experience: tested in lab and works as expected
  - Comment: the feature gives the ability to choose to apply the delay to FRR protected entry only
  - Report last update: 10-11-2017
- Implementation 2:
  - Organization: Cisco
  - Implementation name: Local Microloop Protection

* Operating system: IOS-XR

* Level of maturity: deployed

* Coverage: all the specification is implemented

* Protocols supported: ISIS and OSPF

* Implementation experience: deployed and works as expected

* Comment: the feature gives the ability to choose to apply the delay to FRR protected entry only

* Report last update: 10-11-2017

o Implementation 3:

* Organization: Juniper Networks

* Implementation name: Microloop avoidance when IS-IS link fails

* Operating system: JUNOS

* Level of maturity: deployed (hidden command)

* Coverage: all the specification is implemented

* Protocols supported: ISIS only

* Implementation experience: deployed and works as expected

* Comment: the feature applies to all the ISIS routes

* Report last update: 10-11-2017

12. Security Considerations

This document does not introduce any change in term of IGP security. The operation is internal to the router. The local delay does not increase the number of attack vectors as an attacker could only trigger this mechanism if he already has be ability to disable or

enable an IGP link. The local delay does not increase the negative consequences. If an attacker has the ability to disable or enable an IGP link, it can already harm the network by creating instability and harm the traffic by creating forwarding packet loss and forwarding loss for the traffic crossing that link.

13. Acknowledgements

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14. IANA Considerations

This document has no actions for IANA.

15. References

15.1. Normative References

[ISO10589] "Intermediate System to Intermediate System intra-domain routeing information exchange protocol for use in conjunction with the protocol for providing the connectionless-mode network service (ISO 8473)", ISO 10589, 2002.

[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>.

[RFC2328] Moy, J., "OSPF Version 2", STD 54, RFC 2328, DOI 10.17487/RFC2328, April 1998, <https://www.rfc-editor.org/info/rfc2328>.

15.2. Informative References

[I-D.ietf-rtgwg-backoff-algo] Decraene, B., Litkowski, S., Gredler, H., Lindem, A.,

Francois, P., and C. Bowers, "SPF Back-off algorithm for link state IGPs", draft-ietf-rtgwg-backoff-algo-06 (work in progress), October 2017.

[I-D.ietf-rtgwg-microloop-analysis] Zinin, A., "Analysis and Minimization of Microloops in Link-state Routing Protocols", draft-ietf-rtgwg-microloop-analysis-01 (work in progress), October 2005.

[RFC3906] Shen, N. and H. Smit, "Calculating Interior Gateway Protocol (IGP) Routes Over Traffic Engineering Tunnels", RFC 3906, DOI 10.17487/RFC3906, October 2004, <https://www.rfc-editor.org/info/rfc3906>.

[RFC5715] Shand, M. and S. Bryant, "A Framework for Loop-Free Convergence", RFC 5715, DOI 10.17487/RFC5715, January 2010, <https://www.rfc-editor.org/info/rfc5715>.

[RFC6976] Shand, M., Bryant, S., Previdi, S., Filsfils, C., Francois, P., and O. Bonaventure, "Framework for Loop-Free Convergence Using the Ordered Forwarding Information Base (oFIB) Approach", RFC 6976, DOI 10.17487/RFC6976, July 2013, <https://www.rfc-editor.org/info/rfc6976>.

[RFC7916] Litkowski, S., Ed., Decraene, B., Filsfils, C., Raza, K., Horneffer, M., and P. Sarkar, "Operational Management of Loop-Free Alternates", RFC 7916, DOI 10.17487/RFC7916, July 2016, <https://www.rfc-editor.org/info/rfc7916>.

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