Operational management of Loop Free Alternates
draft-ietf-rtgwg-lfa-manageability-04

Abstract

   Loop Free Alternates (LFA), as defined in RFC 5286 is an IP Fast
   ReRoute (IP FRR) mechanism enabling traffic protection for IP traffic
   (and MPLS LDP traffic by extension). Following first deployment
   experiences, this document provides operational feedback on LFA,
   highlights some limitations, and proposes a set of refinements to
   address those limitations. It also proposes required management
   specifications.

   This proposal is also applicable to remote LFA solution.

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.

   Internet-Drafts are working documents of the Internet Engineering
   Task Force (IETF). Note that other groups may also distribute
   working documents as Internet-Drafts. The list of current Internet-
   Drafts is at http://datatracker.ietf.org/drafts/current/.

   Internet-Drafts are draft documents valid for a maximum of six months
   and may be updated, replaced, or obsoleted by other documents at any
   time. It is inappropriate to use Internet-Drafts as reference
   material or to cite them other than as "work in progress."

   This Internet-Draft will expire on February 12, 2015.

Table of Contents

1. Introduction

Following the first deployments of Loop Free Alternates (LFA), this
document provides feedback to the community about the management of
LFA.

   Section 2 provides real uses cases illustrating some limitations
   and suboptimal behavior.

   Section 4 proposes requirements for activation granularity and
   policy based selection of the alternate.

   Section 5 express requirements for the operational management of
   LFA.

2. Operational issues with default LFA tie breakers

[RFC5286] introduces the notion of tie breakers when selecting the
LFA among multiple candidate alternate next-hops. When multiple LFA
exist, RFC 5286 has favored the selection of the LFA providing the
best coverage of the failure cases. While this is indeed a goal,
this is one among multiple and in some deployment this lead to the
selection of a suboptimal LFA. The following sections details real
use cases of such limitations.

Note that the use case of per-prefix LFA is assumed throughout this
analysis.

2.1. Case 1: Edge router protecting core failures
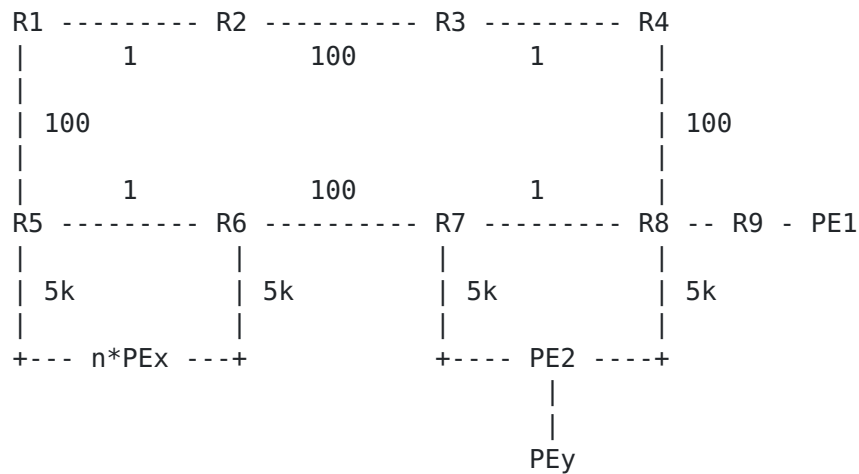
```
    R1 --------- R2 ---------- R3 --------- R4
    |       1            100          1       |
    |                                         |
    | 100                                     | 100
    |                                         |
    |       1            100          1       |
    R5 --------- R6 ---------- R7 --------- R8 -- R9 - PE1
    |            |            |            |
    | 5k         | 5k         | 5k         | 5k
    |            |            |            |
    +--- n*PEx ---+           +---- PE2 ----+
                                    |
                                    |
                                   PEy


                        Figure 1
```

Rx routers are core routers using n*10G links. PEs are connected
using links with lower bandwidth. PEx are a set of PEs connected to
R5 and R6.

In figure 1, let us consider the traffic flowing from PE1 to PEx.
The nominal path is R9-R8-R7-R6-PEx. Let us consider the failure of
link R7-R8. For R8, R4 is not an LFA and the only available LFA is
PE2.

When the core link R8-R7 fails, R8 switches all traffic destined to
all the PEx towards the edge node PE2. Hence an edge node and edge
links are used to protect the failure of a core link. Typically,
edge links have less capacity than core links and congestion may
occur on PE2 links. Note that although PE2 was not directly affected
by the failure, its links become congested and its traffic will
suffer from the congestion.

In summary, in case of failure, the impact on customer traffic is:

o From PE2 point of view :

   * without LFA: no impact

   * with LFA: traffic is partially dropped (but possibly
      prioritized by a QoS mechanism). It must be highlighted that
      in such situation, traffic not affected by the failure may be
      affected by the congestion.

o From R8 point of view:

      * without LFA: traffic is totally dropped until convergence
         occurs.

      * with LFA: traffic is partially dropped (but possibly
         prioritized by a QoS mechanism).

   Besides the congestion aspects of using an Edge router as an
   alternate to protect a core failure, a service provider may consider
   this as a bad routing design and would like to prevent it.

2.2. Case 2: Edge router choosen to protect core failures while core LFA exists

```
      R1 --------- R2 ------------ R3 --------- R4
      |     1            100        |     1      |
      |                             |            |
      | 100                         | 30         | 30
      |                             |            |
      |     1         50        50  |    10      |
      R5 -------- R6 ---- R10 ---- R7 -------- R8 --- R9 - PE1
      |           |          \                  |
      | 5000      | 5000      \ 5000             | 5000
      |           |            \                 |
      +--- n*PEx --+            +----- PE2 ----+
                                      |
                                      |
                                     PEy
```
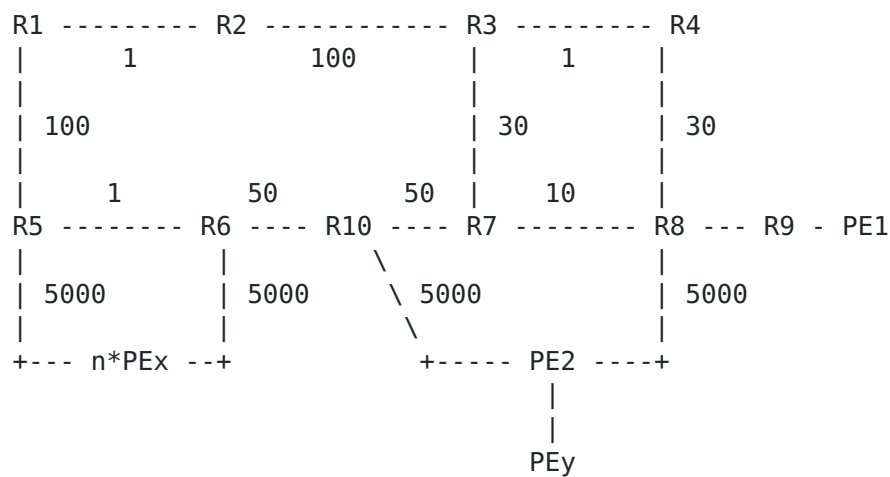
                            Figure 2

   Rx routers are core routers meshed with n*10G links. PEs are meshed
   using links with lower bandwidth.

   In the figure 2, let us consider the traffic coming from PE1 to PEx.
   Nominal path is R9-R8-R7-R10-R6-PEx. Let us consider the failure of
   the link R7-R8. For R8, R4 is a link-protecting LFA and PE2 is a
   node-protecting LFA. PE2 is chosen as best LFA due to its better
   protection type. Just like in case 1, this may lead to congestion on
   PE2 links upon LFA activation.

2.3. Case 3: suboptimal core alternate choice

```
               +--- PE3 --+
              /            \
        1000 /              \ 1000
            /                \
       +----- R1 --------------- R2 ----+
       |     |      500        |       |
       | 10  |                 |       | 10
       |     |                 |       |
       R5    | 10              | 10    R7
       |     |                 |       |
       | 10  |                 |       | 10
       |     |      500        |       |
      +---- R3 --------------- R4 -----+
            \                 /
        1000 \               / 1000
              \             /
               +--- PE1 ---+
```
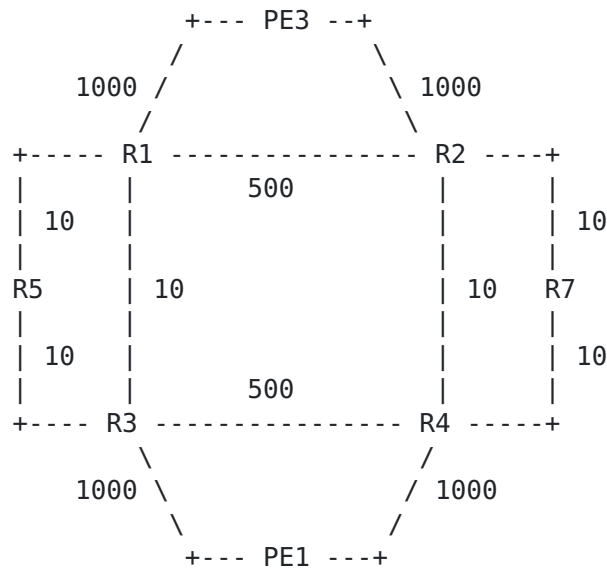
                    Figure 3

   Rx routers are core routers. R1-R2 and R3-R4 links are 1G links.
   All others inter Rx links are 10G links.

   In the figure above, let us consider the failure of link R1-R3. For
   destination PE3, R3 has two possible alternates:

   o R4, which is node-protecting

   o R5, which is link-protecting

   R4 is chosen as best LFA due to its better protection type. However,
   it may not be desirable to use R4 for bandwidth capacity reason. A
   service provider may prefer to use high bandwidth links as prefered
   LFA. In this example, prefering shortest path over protection type
   may achieve the expected behavior, but in cases where metric are not
   reflecting bandwidth, it would not work and some other criteria would
   need to be involved when selecting the best LFA.

2.4. Case 4: ISIS overload bit on LFA computing node

```
       P1         P2
       |   \   /    |
   50  | 50 \/ 50 | 50
       |    /\      |
     PE1-+  +-- PE2
       \          /
    45 \       / 45
         -PE3-+
         (OL set)
```

                Figure 4

   In the figure above, PE3 has its overload bit set (permanently, for
   design reason) and wants to protect traffic using LFA for destination
   PE2.

   On PE3, the loopfree condition is not satisified : 100 !< 45 + 45.
   PE1 is thus not considered as an LFA. However thanks to the overload
   bit set on PE3, we know that PE1 is loopfree so PE1 is an LFA to
   reach PE2.

   In case of overload condition set on a node, LFA behavior must be
   clarified.

3. Need for coverage monitoring

   As per [RFC6571], LFA coverage highly depends on the used network
   topology. Even if remote LFA ([I-D.ietf-rtgwg-remote-lfa]) extends
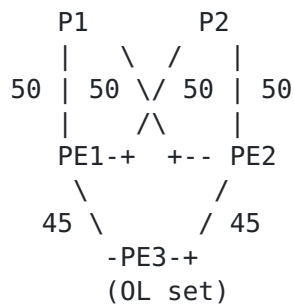   significantly the coverage of the basic LFA specification, there is
   still some cases where protection would not be available. As network
   topologies are constantly evolving (network extension, capacity
   addings, latency optimization ...), the protection coverage may
   change. Fast reroute functionality may be critical for some services
   supported by the network, a service provider must constantly know
   what protection coverage is currently available on the network.
   Moreover, predicting the protection coverage in case of network
   topology change is mandatory.

   Today network simulation tool associated with whatif scenarios
   functionnality are often used by service providers for the overall
   network design (capacity, path optimization ...). Section 6.5,
   Section 6.4 and Section 6.3 of this document propose to add LFA
   informations into such tool and within routers, so a service provider
   may be able :

   o to evaluate protection coverage after a topology change.

   o to adjust the topology change to cover the primary need (e.g.
      latency optimization or bandwidth increase) as well as LFA
      protection.

   o monitor constantly the LFA coverage in the live network and being
      alerted.

4. Need for LFA activation granularity

   As all FRR mechanism, LFA installs backup paths in Forwarding
   Information Base (FIB). Depending of the hardware used by a service
   provider, FIB ressource may be critical. Activating LFA, by default,
   on all available components (IGP topologies, interface, address
   families ...) may lead to waste of FIB ressource as generally in a
   network only few destinations should be protected (e.g. loopback
   addresses supporting MPLS services) compared to the amount of
   destinations in RIB.

   Moreover a service provider may implement multiple different FRR
   mechanism in its networks for different usages (MRT, TE FRR),
   computing LFAs for prefixes or interfaces that are already protected
   by another mechanism is useless.

   Section 5 of this document propose some implementation guidelines.

5. Configuration requirements

   Controlling best alternate and LFA activation granularity is a
   requirement for Service Providers. This section defines
   configuration requirements for LFA.

5.1. LFA enabling/disabling scope

   The granularity of LFA activation should be controlled (as alternate
   nexthop consume memory in forwarding plane).

   An implementation of LFA SHOULD allow its activation with the
   following criteria:

   o Per address-family : ipv4 unicast, ipv6 unicast, LDP IPv4 unicast,
      LDP IPv6 unicast ...

   o Per routing context : VRF, virtual/logical router, global routing
      table, ...

   o Per interface

   o Per protocol instance, topology, area

o Per prefixes: prefix protection SHOULD have a better priority
   compared to interface protection. This means that if a specific
   prefix must be protected due to a configuration request, LFA must
   be computed and installed for this prefix even if the primary
   outgoing interface is not configured for protection.

5.2. Policy based LFA selection

When multiple alternates exist, LFA selection algorithm is based on
tie breakers. Current tie breakers do not provide sufficient control
on how the best alternate is chosen. This document proposes an
enhanced tie breaker allowing service providers to manage all
specific cases:

1. An implementation of LFA SHOULD support policy-based decision for
    determining the best LFA.

2. Policy based decision SHOULD be based on multiple criterions,
    with each criteria having a level of preference.

3. If the defined policy does not permit to determine a unique best
    LFA, an implementation SHOULD pick only one based on its own
    decision, as a default behavior. An implementation SHOULD also
    support election of multiple LFAs, for loadbalancing purposes.

4. Policy SHOULD be applicable to a protected interface or to a
    specific set of destinations. In case of application on the
    protected interface, all destinations primarily routed on this
    interface SHOULD use the interface policy.

5. It is an implementation choice to reevaluate policy dynamically
    or not (in case of policy change). If a dynamic approach is
    chosen, the implementation SHOULD recompute the best LFAs and
    reinstall them in FIB, without service disruption. If a non-
    dynamic approach is chosen, the policy would be taken into
    account upon the next IGP event. In this case, the
    implementation SHOULD support a command to manually force the
    recomputation/reinstallation of LFAs.

5.2.1. Connected vs remote alternates

In addition to direct LFAs, tunnels (e.g. IP, LDP or RSVP-TE) to
distant routers may be used to complement LFA coverage (tunnel tail
used as virtual neighbor). When a router has multiple alternate
candidates for a specific destination, it may have connected
alternates and remote alternates reachable via a tunnel. Connected
alternates may not always provide an optimal routing path and it may
be preferable to select a remote alternate over a connected

alternate. The usage of tunnels to extend LFA coverage is described
in [I-D.ietf-rtgwg-remote-lfa].

In figure 1, there is no core alternate for R8 to reach PEs located
behind R6, so R8 is using PE2 as alternate, which may generate
congestion when FRR is activated. Instead, we could have a remote
core alternate for R8 to protect PEs destinations. For example, a
tunnel from R8 to R3 would ensure LFA protection without using an
edge router to protect a core router.

When selecting the best alternate, the selection algorithm MUST
consider all available alternates (connected or tunnel). Especially,
computation of PQ set ([I-D.ietf-rtgwg-remote-lfa]) SHOULD be
performed before best alternate selection.

5.2.2. Mandatory criteria

An implementation of LFA MUST support the following criteria:

o Non candidate link: A link marked as "non candidate" will never be
   used as LFA.

o A primary nexthop being protected by another primary nexthop of
   the same prefix (ECMP case).

o Type of protection provided by the alternate: link protection,
   node protection. In case of node protection preference, an
   implementation SHOULD support fallback to link protection if node
   protection is not available.

o Shortest path: lowest IGP metric used to reach the destination.

o SRLG (as defined in [RFC5286] Section 3, see also Section 5.2.6
   for more details).

5.2.3. Enhanced criteria

An implementation of LFA SHOULD support the following enhanced
criteria:

o Downstreamness of an alternate : preference of a downstream path
   over a non downstream path SHOULD be configurable.

o Link coloring with : include, exclude and preference based system
   (see Section 5.2.7).

o Link Bandwidth (see Section 5.2.8).

o Alternate preference (see Section 5.2.9).

5.2.4. Retrieving alternate path attributes

The policy to select the best alternate evaluate multiple criterions
(e.g. metric, SRLG, link colors ...) which first need to be computed
for each alternate.. In order to compare the different alternate
path, a router must retrieve the attributes of each alternate path.
The alternate path is composed of two distinct parts : PLR to
alternate and alternate to destination.

5.2.4.1. Connected alternate

For alternate path using a connected alternate :

o attributes from PLR to alternate path are retrieved from the
   interface connected to the alternate.

o attributes from alternate to destination path are retrieved from
   SPF rooted at the alternate. As the alternate is a connected
   alternate, the SPF has already been computed to find the
   alternate, so there is no need of additional computation.

5.2.4.2. Remote alternate

For alternate path using a remote alternate (tunnel) :

o attributes from the PLR to alternate path are retrieved using the
   PLR's primary SPF if P space is used or using the neighbor's SPF
   if extended P space is used, combined with the attributes of the
   link(s) to reach that neighbor. In both cases, no additional SPF
   is required.

o attributes from alternate to destination path are retrieved from
   SPF rooted at the remote alternate. An additional forward SPF is
   required for each remote alternate as indicated in
   [I-D.psarkar-rtgwg-rlfa-node-protection] section 3.2..

The number of remote alternates may be very high, simulations shown
that hundred's of PQs may exist for a single interface being
protected. Running a forward SPF for every PQ-node in the network is
not scalable.

To handle this situation, it is needed to limit the number of remote
alternates to be evaluated to a finite number before collecting
alternate path attributes and running the policy evaluation. [I-
D.psarkar-rtgwg-rlfa-node-protection] Section 2.3.3 provides a way to
reduce the number of PQ to be evaluated.

```
                   Link              Remote             Remote
                   alternate         alternate          alternate
                   -------------     -------------------     -------------
    Alternates    |  LFA       |    |   rLFA (PQs)     |    |  Static    |
    sources       |            |    |                  |    |  tunnels   |
                   -------------     -------------------     -------------
                        |                    |                     |
                        |                    |                     |
                        |          ----------------------          |
                        |         |  Prune some PQs     |          |
                        |         | (sorting strategy)  |          |
                        |          ----------------------          |
                        |                    |                     |
                        |                    |                     |
                   ----------------------------------------------------
                  |         Collect alternate attributes            |
                   ----------------------------------------------------
                                       |
                                       |
                            -------------------------
                           |    Evaluate policy      |
                            -------------------------
                                       |
                                       |
                                 Best alternates
```

5.2.5. ECMP LFAs

```
            10
      PE2 - PE3
       |     |
   50  |  5  | 50
       P1----P2
        \\    //
   50    \\  // 50
          PE1
```
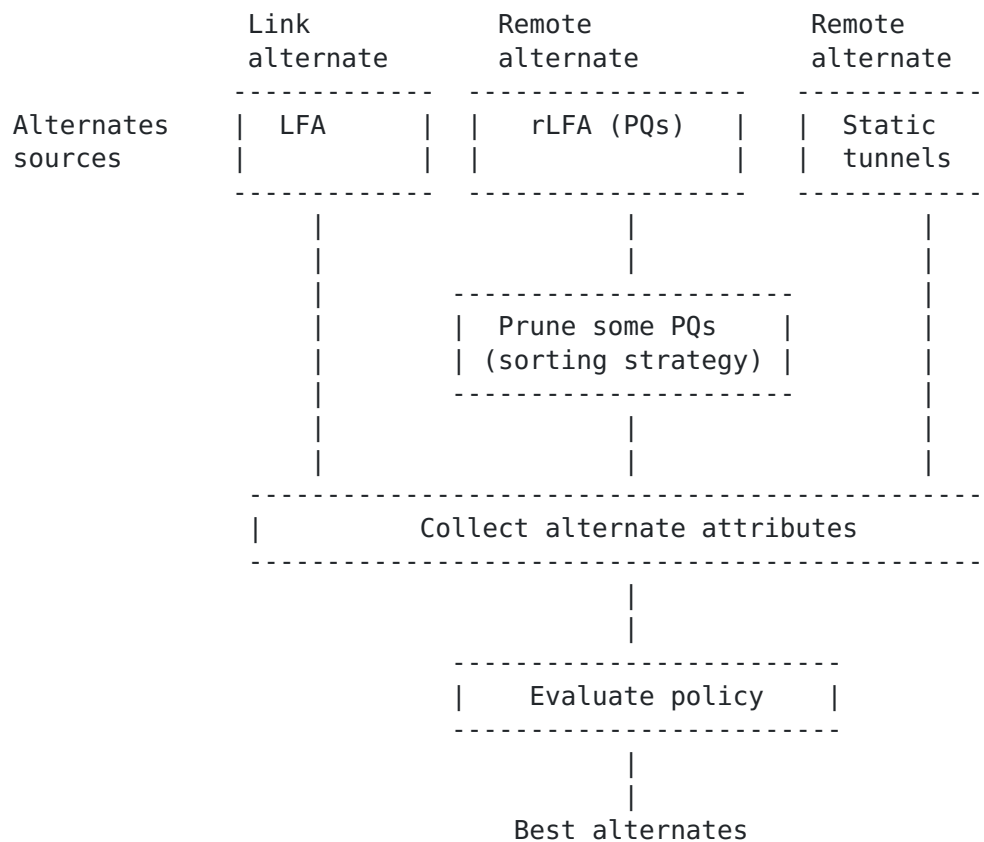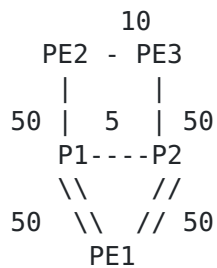
      Figure 5

   Links between P1 and PE1 are L1 and L2, links between P2 and PE1 are
   L3 and L4

   In the figure above, primary path from PE1 to PE2 is through P1 using
   ECMP on two parallel links L1 and L2. In case of standard ECMP
   behavior, if L1 is failing, postconvergence nexthop would become L2
   and there would be no longer ECMP. If LFA is activated, as stated in
   [RFC5286] Section 3.4., "alternate next-hops may themselves also be
   primary next-hops, but need not be" and "alternate next-hops should

maximize the coverage of the failure cases". In this scenario there
is no alternate providing node protection, LFA will so prefer L2 as
alternate to protect L1 which makes sense compared to postconvergence
behavior.

Considering a different scenario using figure 5, where L1 and L2 are
configured as a layer 3 bundle using a local feature, as well as L3/
L4 being a second layer 3 bundle. Layer 3 bundles are configured as
if a link in the bundle is failing, the traffic must be rerouted out
of the bundle. Layer 3 bundles are generally introduced to increase
bandwidth between nodes. In nominal situation, ECMP is still
available from PE1 to PE2, but if L1 is failing, postconvergence
nexthop would become ECMP on L3 and L4. In this case, LFA behavior
SHOULD be adapted in order to reflect the bandwidth requirement.

We would expect the following FIB entry on PE1 :

```
    On PE1 : PE2 +--> ECMP -> L1
                 |      |
                 |      +----> L2
                 |
                 +--> LFA(ECMP) -> L3
                         |
                         +---------> L4
```

If L1 or L2 is failing, traffic must be switched on the LFA ECMP
bundle rather than using the other primary nexthop.

As mentioned in [RFC5286] Section 3.4., protecting a link within an
ECMP by another primary nexthop is not a MUST. Moreover, we already
presented in this document, that maximizing the coverage of the
failure case may not be the right approach and policy based choice of
alternate may be preferred.

An implementation SHOULD permit to prefer a primary nexthop by
another primary nexthop with the possibility to deactivate this
criteria. An implementation SHOULD permit to use an ECMP bundle as a
LFA.

5.2.6. SRLG

[RFC5286] Section 3. proposes to reuse GMPLS IGP extensions to encode
SRLGs ([RFC4205] and [RFC4203]). The section is also describing the
algorithm to compute SRLG protection.

When SRLG protection is computed, and implementation SHOULD permit to
:

o Exclude alternates violating SRLG.

o Maintain a preference system between alternates based on number of
   SRLG violations : more violations = less preference.

When applying SRLG criteria, the SRLG violation check SHOULD be
performed on source to alternate as well as alternate to destination
paths. In the case of remote LFA, PQ to destination path attributes
would be retrieved from SPT rooted at PQ.

5.2.7. Link coloring

Link coloring is a powerful system to control the choice of
alternates. Protecting interfaces are tagged with colors. Protected
interfaces are configured to include some colors with a preference
level, and exclude others.

Link color information SHOULD be signalled in the IGP. How
signalling is done is out of scope of the document but it may be
useful to reuse existing admin-groups from traffic-engineering
extensions.

```
              PE2
              |    +---- P4
              |  /
      PE1 ---- P1 --------- P2
              |        10Gb
        1Gb |
              |
              P3
```
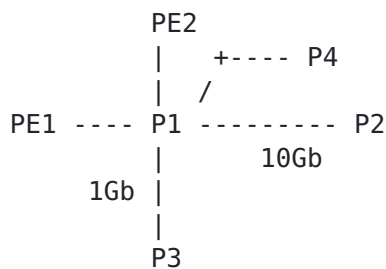
         Figure 5

Example : P1 router is connected to three P routers and two PEs.

P1 is configured to protect the P1-P4 link. We assume that given the
topology, all neighbors are candidate LFA. We would like to enforce
a policy in the network where only a core router may protect against
the failure of a core link, and where high capacity links are
prefered.

In this example, we can use the proposed link coloring by:

o Marking PEs links with color RED

o Marking 10Gb CORE link with color BLUE

o Marking 1Gb CORE link with color YELLOW

o Configured the protected interface P1->P4 with :

   * Include BLUE, preference 200

   * Include YELLOW, preference 100

   * Exclude RED

Using this, PE links will never be used to protect against P1-P4 link failure and 10Gb link will be be preferred.

The main advantage of this solution is that it can easily be duplicated on other interfaces and other nodes without change. A Service Provider has only to define the color system (associate color with a significance), as it is done already for TE affinities or BGP communities.

An implementation of link coloring:

o SHOULD support multiple include and exclude colors on a single protected interface.

o SHOULD provide a level of preference between included colors.

o SHOULD support multiple colors configuration on a single protecting interface.

5.2.8. Bandwidth

As mentionned in previous sections, not taking into account bandwidth of an alternate could lead to congestion during FRR activation. We propose to base the bandwidth criteria on the link speed information for the following reason :

o if a router S has a set of X destinations primarly forwarded to N, using per prefix LFA may lead to have a subset of X protected by a neighbor N1, another subset by N2, another subset by Nx ...

o S is not aware about traffic flows to each destination and is not able to evaluate how much traffic will be sent to N1,N2, ... Nx in case of FRR activation.

Based on this, it is not useful to gather available bandwidth on alternate paths, as the router does not know how much bandwidth it

requires for protection. The proposed link speed approach provides a
good approximation with a small cost as information is easily
available.

The bandwidth criteria of the policy framework SHOULD work in two
ways :

o PRUNE : exclude a LFA if link speed to reach it is lower than the
   link speed of the primary nexthop interface.

o PREFER : prefer a LFA based on his bandwidth to reach it compared
   to the link speed of the primary nexthop interface.

5.2.9. Alternate preference

Rather than tagging interface on each node (using link color) to
identify alternate node type (as example), it would be helpful if
routers could be identified in the IGP. This would permit a grouped
processing on multiple nodes. As an implementation need to exclude
some specific alternates (see Section 5.2.3), an implementation :

o SHOULD be able to give a preference to specific alternate.

o SHOULD be able to give a preference to a group of alternate.

o SHOULD be able to exclude a group of alternate.

A specific alternate may be identified by its interface, IP address
or router ID and group of alternates may be identified by a marker
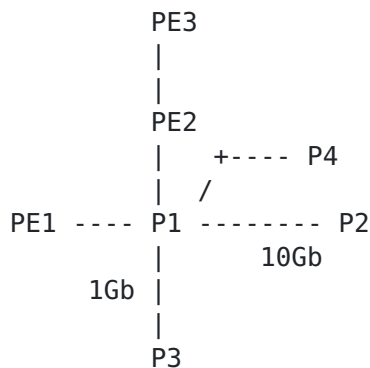(tag).

Consider the following network:

```
              PE3
               |
               |
              PE2
               |    +---- P4
               |   /
     PE1 ---- P1 -------- P2
               |        10Gb
          1Gb  |
               |
              P3


         Figure 6
```

In the example above, each node is configured with a specific tag
flooded through the IGP.

o PE1,PE3: 200 (non candidate).

o PE2: 100 (edge/core).

o P1,P2,P3: 50 (core).

A simple policy could be configured on P1 to choose the best
alternate for P1->P4 based on router function/role as follows :

o criteria 1 -> alternate preference: exclude tag 100 and 200.

o criteria 2 -> bandwidth.

6. Operational aspects

6.1. ISIS overload bit on LFA computing node

In [RFC5286], Section 3.5, the setting of the overload bit condition
in LFA computation is only taken into account for the case where a
neighbor has the overload bit set.

In addition to RFC 5286 inequality 1 Loop-Free Criterion
(Distance_opt(N, D) < Distance_opt(N, S) + Distance_opt(S, D)), the
IS-IS overload bit of the LFA calculating neighbor (S) SHOULD be
taken into account. Indeed, if it has the overload bit set, no
neighbor will loop back to traffic to itself.

6.2. Manual triggering of FRR

Service providers often perform manual link shutdown (using router
CLI) to perform some network changes/tests. A manual link shutdown
may be done at multiple level : physical interface, logical
interface, IGP interface, BFD session ... Especially testing or
troubleshooting FRR requires to perform the manual shutdown on the
remote end of the link as generally a local shutdown would not
trigger FRR.

To enhance such situation, an implementation SHOULD support
triggering/activating LFA Fast Reroute for a given link when a manual
shutdown is done on a component that currently supports FRR
activation.

For example :

o if an implementation supports FRR activation upon BFD session down
   event, this implementation SHOULD support FRR activation when a
   manual shutdown is done on the BFD session. But if an
   implementation does not support FRR activation on BFD session
   down, there is no need for this implementation to support FRR
   activation on manual shutdown of BFD session.

o if an implementation supports FRR activation on physical link down
   event (e.g. Rx laser Off detection, or error threshold raised
   ...), this implementation SHOULD support FRR activation when a
   manual shutdown at physical interface is done. But if an
   implementation does not support FRR activation on physical link
   down event, there is no need for this implementation to support
   FRR activation on manual physical link shutdown.

6.3. Required local information

LFA introduction requires some enhancement in standard routing
information provided by implementations. Moreover, due to the non
100% coverage, coverage informations is also required.

Hence an implementation :

o MUST be able to display, for every prefixes, the primary nexthop
   as well as the alternate nexthop information.

o MUST provide coverage information per activation domain of LFA
   (area, level, topology, instance, virtual router, address family
   ...).

o MUST provide number of protected prefixes as well as non protected
   prefixes globally.

o SHOULD provide number of protected prefixes as well as non
   protected prefixes per link.

o MAY provide number of protected prefixes as well as non protected
   prefixes per priority if implementation supports prefix-priority
   insertion in RIB/FIB.

o SHOULD provide a reason for chosing an alternate (policy and
   criteria) and for excluding an alternate.

o SHOULD provide the list of non protected prefixes and the reason
   why they are not protected (no protection required or no alternate
   available).

6.4. Coverage monitoring

It is pretty easy to evaluate the coverage of a network in a nominal situation, but topology changes may change the coverage. In some situations, the network may no longer be able to provide the required level of protection. Hence, it becomes very important for service providers to get alerted about changes of coverage.

An implementation SHOULD :

o provide an alert system if total coverage (for a node) is below a defined threshold or comes back to a normal situation.

o provide an alert system if coverage of a specific link is below a defined threshold or comes back to a normal situation.

An implementation MAY :

o provide an alert system if a specific destination is not protected anymore or when protection comes back up for this destination

Although the procedures for providing alerts are beyond the scope of this document, we recommend that implementations consider standard and well used mechanisms like syslog or SNMP traps.

6.5. LFA and network planning

The operator may choose to run simulations in order to ensure full coverage of a certain type for the whole network or a given subset of the network. This is particularly likely if he operates the network in the sense of the third backbone profiles described in [RFC6571], that is, he seeks to design and engineer the network topology in a way that a certain coverage is always achieved. Obviously a complete and exact simulation of the IP FRR coverage can only be achieved, if the behavior is deterministic and if the algorithm used is available to the simulation tool. Thus, an implementation SHOULD:

o Behave deterministic in its selection LFA process. I.e. in the same topology and with the same policy configuration, the implementation MUST always choose the same alternate for a given prefix.

o Document its behavior. The implementation SHOULD provide enough documentation of its behavior that allows an implementer of a simulation tool, to foresee the exact choice of the LFA implementation for every prefix in a given topology. This SHOULD take into account all possible policy configuration options. One

possible way to document this behavior is to disclose the
algorithm used to choose alternates.

7. Security Considerations

This document does not introduce any change in security consideration
compared to [RFC5286].

8. Contributors

Significant contributions were made by Pierre Francois, Hannes
Gredler, Chris Bowers, Jeff Tantsura, Uma Chunduri and Mustapha
Aissaoui which the authors would like to acknowledge.

9. Acknowledgements

10. IANA Considerations

This document has no action for IANA.

11. References

11.1. Normative References

[RFC2119]   Bradner, S., "Key words for use in RFCs to Indicate
            Requirement Levels", BCP 14, RFC 2119, March 1997.

[RFC4203]   Kompella, K. and Y. Rekhter, "OSPF Extensions in Support
            of Generalized Multi-Protocol Label Switching (GMPLS)",
            RFC 4203, October 2005.

[RFC4205]   Kompella, K. and Y. Rekhter, "Intermediate System to
            Intermediate System (IS-IS) Extensions in Support of
            Generalized Multi-Protocol Label Switching (GMPLS)", RFC
            4205, October 2005.

[RFC5286]   Atlas, A. and A. Zinin, "Basic Specification for IP Fast
            Reroute: Loop-Free Alternates", RFC 5286, September 2008.

11.2. Informative References

[I-D.ietf-rtgwg-remote-lfa]
            Bryant, S., Filsfils, C., Previdi, S., Shand, M., and S.
            Ning, "Remote LFA FRR", draft-ietf-rtgwg-remote-lfa-06
            (work in progress), May 2014.

[I-D.litkowski-rtgwg-lfa-rsvpte-cooperation]
          Litkowski, S., Decraene, B., Filsfils, C., and K. Raza,
          "Interactions between LFA and RSVP-TE", draft-litkowski-
          rtgwg-lfa-rsvpte-cooperation-02 (work in progress), August
          2013.

[I-D.psarkar-isis-node-admin-tag]
          psarkar@juniper.net, p., Gredler, H., Hegde, S.,
          Litkowski, S., Decraene, B., Li, Z., and H. Raghuveer,
          "Advertising Per-node Admin Tags in IS-IS", draft-psarkar-
          isis-node-admin-tag-02 (work in progress), July 2014.

[I-D.psarkar-rtgwg-rlfa-node-protection]
          psarkar@juniper.net, p., Gredler, H., Hegde, S., Bowers,
          C., Litkowski, S., and H. Raghuveer, "Remote-LFA Node
          Protection and Manageability", draft-psarkar-rtgwg-rlfa-
          node-protection-05 (work in progress), June 2014.

[RFC3630] Katz, D., Kompella, K., and D. Yeung, "Traffic Engineering
           (TE) Extensions to OSPF Version 2", RFC 3630, September
           2003.

[RFC3906] Shen, N. and H. Smit, "Calculating Interior Gateway
           Protocol (IGP) Routes Over Traffic Engineering Tunnels",
           RFC 3906, October 2004.

[RFC4090] Pan, P., Swallow, G., and A. Atlas, "Fast Reroute
           Extensions to RSVP-TE for LSP Tunnels", RFC 4090, May
           2005.

[RFC5305] Li, T. and H. Smit, "IS-IS Extensions for Traffic
           Engineering", RFC 5305, October 2008.

[RFC5714] Shand, M. and S. Bryant, "IP Fast Reroute Framework", RFC
           5714, January 2010.

[RFC5715] Shand, M. and S. Bryant, "A Framework for Loop-Free
           Convergence", RFC 5715, January 2010.

[RFC6571] Filsfils, C., Francois, P., Shand, M., Decraene, B.,
           Uttaro, J., Leymann, N., and M. Horneffer, "Loop-Free
           Alternate (LFA) Applicability in Service Provider (SP)
           Networks", RFC 6571, June 2012.

Authors' Addresses

   Stephane Litkowski
   Orange

   Email: stephane.litkowski@orange.com

   Bruno Decraene
   Orange

   Email: bruno.decraene@orange.com

   Clarence Filsfils
   Cisco Systems

   Email: cfilsfil@cisco.com

   Kamran Raza
   Cisco Systems

   Email: skraza@cisco.com

   Martin Horneffer
   Deutsche Telekom

   Email: Martin.Horneffer@telekom.de

   Pushpasis Sarkar
   Juniper Networks

   Email: psarkar@juniper.net