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**LFA selection for Multi-Homed Prefixes**  
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Abstract

This document shares experience gained from implementing algorithms to determine Loop-Free Alternates for multi-homed prefixes. In particular, this document provides explicit inequalities that can be used to evaluate neighbours as a potential alternates for multi-homed prefixes. It also provides detailed criteria for evaluating potential alternates for external prefixes advertised by OSPF ASBRs.

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](#) [[RFC2119](#)].

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## [1.](#) Introduction

The use of Loop-Free Alternates (LFA) for IP Fast Reroute is specified in [\[RFC5286\]](#). [Section 6.1 of \[RFC5286\]](#) describes a method to determine loop-free alternates for a multi-homed prefixes (MHPs). This document describes a procedure using explicit inequalities that can be used by a computing router to evaluate a neighbour as a potential alternate for a multi-homed prefix. The results obtained are equivalent to those obtained using the method described in [Section 6.1 of \[RFC5286\]](#). However, some may find this formulation useful.

[Section 6.3 of \[RFC5286\]](#) discusses complications associated with computing LFAs for multi-homed prefixes in OSPF. This document



provides detailed criteria for evaluating potential alternates for external prefixes advertised by OSPF ASBRs, as well as explicit inequalities.

## 2. LFA inequalities for MHPs

The following set of inequalities can be used to evaluate LFAs for multi-homed prefixes.

This document proposes the following set of LFA inequalities for selecting the most appropriate LFAs for multi-homed prefixes (MHPs). They can be derived from the inequalities in [[RFC5286](#)] combined with the observation that  $D_{\text{opt}}(N,P) = \text{Min} (D_{\text{opt}}(N,PO\_i) + \text{cost}(PO\_i,P))$  over all  $PO\_i$

Link-Protection:

$$D_{\text{opt}}(N,PO\_i) + \text{cost}(PO\_i,P) < D_{\text{opt}}(N,S) + D_{\text{opt}}(S,PO\_best) + \text{cost}(PO\_best,P)$$

Link-Protection + Downstream-paths-only:

$$D_{\text{opt}}(N,PO\_i) + \text{cost}(PO\_i,P) < D_{\text{opt}}(S,PO\_best) + \text{cost}(PO\_best,P)$$

Node-Protection:

$$D_{\text{opt}}(N,PO\_i) + \text{cost}(PO\_i,P) < D_{\text{opt}}(N,E) + D_{\text{opt}}(E,PO\_best) + \text{cost}(PO\_best,P)$$

Where,

- S                - The computing router
- N                - The alternate router being evaluated
- E                - The primary next-hop on shortest path from S to prefix P.
- PO\_i            - The specific prefix-originating router being evaluated.
- PO\_best        - The prefix-originating router on the shortest path from the computing router S to prefix P.
- Cost (X,P)     - Cost of reaching the prefix P from prefix originating node X.
- D\_opt(X,Y)     - Distance on the shortest path from node X to node Y.

Figure 1: LFA inequalities for MHPs

To compute a valid LFA for a given multi-homed prefix P, a computing router S shall evaluate for each alternate neighbor N, one of the above set of inequalities, once for each remote node that originated the prefix. If the inequality is satisfied by any neighbour N for any remote prefix-originating node, router S shall choose neighbour N, as one of the valid LFAs for the prefix P.



### **3.   LFA selection for the multi-homed external routes**

Redistribution of external routes into IGP is required in case of two different networks getting merged into one or during protocol migrations. External routes could be distributed into an IGP domain via multiple nodes to avoid a single point of failure. During LFA calculation, alternate LFA next-hops to reach the best ASBR could be used as LFA for the routes redistributed via that ASBR. When there is no LFA available to the best ASBR, it may be desirable to consider the other ASBRs (referred to as alternate ASBR hereafter) redistributing the external routes for LFA selection as defined in [[RFC5286](#)] and leverage the advantage of having multiple redistributing nodes in the network.

#### **3.1.   IS-IS**

LFA evaluation for multi-homed external prefixes in IS-IS is similar to the multi-homed internal prefixes. Inequalities described in sec 2 would also apply to multi-homed external prefixes as well.

#### **3.2.   OSPF**

Loop free Alternates [[RFC 5286](#)] describes mechanisms to apply inequalities to find the the loop free alternate neighbour. For the selection of alternate ASBR for LFA consideration, additional rules have to be applied in selecting the alternate ASBR due to the external route calculation rules imposed by [[RFC 2328](#)]. This document also defines the inequalities defined in RFC [5286] specifically for the alternate loop-free ASBR evaluation.

##### **3.2.1.   Rules to select alternate ASBR**

The process to select an alternate ASBR is best explained using the rules below. The below process is applied when primary ASBR for the concerned prefix is chosen and there is an alternate ASBR originating same prefix.



1. If RFC1583Compatibility is disabled
  - 1a. if primary ASBR and alternate ASBR are intra area non-backbone path go to step 2.
  - 1b. If primary ASBR and alternate ASBR belong to intra-area backbone and/or inter-area path go to step 2.
  - 1c. for other paths, skip the alternate ASBR and consider next ASBR.
2. If cost type (type1/type2) advertised by alternate ASBR same as primary
  - 2a. If not same skip alternate ASBR and consider next ASBR.
3. If cost type is type1
  - 3a. If cost is same, program ECMP
  - 3b. else go to step 5.
4. If cost type is type 2
  - 4a. If cost is different, skip alternate ASBR and consider next ASBR
  - 4b. If type2 cost is same, compare type 1 cost.
  - 4c. If type1 cost is also same program ECMP.
  - 4d. If type 1 cost is different go to step 5.
5. If route type (type 5/type 7)
  - 5a. If route type is same, check route p-bit, forwarding address field for routes from both ASBRs  
match. If not skip alternate ASBR and consider next ASBR.
  - 5b. If route type is not same, skip ASBR and consider next ASBR.
6. Apply inequality on the alternate ASBR.

Figure 2: Rules for selecting alternate ASBR in OSPF

### **3.2.2. Multiple ASBRs belonging different area**

When "RFC1583compatibility" is set to disabled, OSPF[RFC2328] defines certain rules of preference to choose the ASBRs. While selecting alternate ASBR for loop evaluation for LFA, these rules should be applied and ensured that the alternate neighbour does not loop the traffic back.

When there are multiple ASBRs belonging to different area advertising the same prefix, pruning rules as defined in [RFC 2328 section 16.4.1](#)





are applied. The alternate ASBRs pruned using above rules are not considered for LFA evaluation.

### **3.2.3.    Type 1 and Type 2 costs**

If there are multiple ASBRs not pruned via rules defined in 3.2.2, the cost type advertised by the ASBRs is compared. ASBRs advertising Type1 costs are preferred and the type2 costs are pruned. If two ASBRs advertise same type2 cost, the alternate ASBRs are considered along with their type1 cost for evaluation. If the two ASBRs with same type2 as well as type1 cost, ECMP FRR is programmed. If there are two ASBRs with different type2 cost, the higher cost ASBR is pruned. The inequalities for evaluating alternate ASBR for type 1 and type 2 costs are same, as the alternate ASBRs with different type2 costs are pruned and the evaluation is based on equal type 2 cost ASBRs.

### **3.2.4.    RFC1583compatibility is set to enabled**

When RFC1583Compatibility is set to enabled, multiple ASBRs belonging to different area advertising same prefix are chosen based on cost and hence are valid alternate ASBRs for the LFA evaluation.

### **3.2.5.    Type 7 routes**

Type 5 routes always get preference over Type 7 and the alternate ASBRs chosen for LFA calculation should belong to same type. Among Type 7 routes, routes with p-bit and forwarding address set have higher preference than routes without these attributes. Alternate ASBRs selected for LFA comparison should have same p-bit and forwarding address attributes.

### **3.2.6.    Inequalities to be applied for alternate ASBR selection**

The alternate ASBRs selected using above mechanism described in 3.2.1, are evaluated for Loop free criteria using below inequalities.

#### **3.2.6.1.    Forwarding address set to non zero value**



Link-Protection:

$$F_{\text{opt}}(N, PO_i) + \text{cost}(PO_i, P) < D_{\text{opt}}(N, S) + F_{\text{opt}}(S, PO_{\text{best}}) + \text{cost}(PO_{\text{best}}, P)$$

Link-Protection + Downstream-paths-only:

$$F_{\text{opt}}(N, PO_i) + \text{cost}(PO_i, P) < F_{\text{opt}}(S, PO_{\text{best}}) + \text{cost}(PO_{\text{best}}, P)$$

Node-Protection:

$$F_{\text{opt}}(N, PO_i) + \text{cost}(PO_i, P) < D_{\text{opt}}(N, E) + F_{\text{opt}}(E, PO_{\text{best}}) + \text{cost}(PO_{\text{best}}, P)$$

Where,

- S - The computing router
- N - The alternate router being evaluated
- E - The primary next-hop on shortest path from S to prefix P.
- PO<sub>i</sub> - The specific prefix-originating router being evaluated.
- PO<sub>best</sub> - The prefix-originating router on the shortest path from the computing router S to prefix P.
- cost(X,Y) - External cost for Y as advertised by X
- F<sub>opt</sub>(X,Y) - Distance on the shortest path from node X to Forwarding address specified by ASBR Y.
- D<sub>opt</sub>(X,Y) - Distance on the shortest path from node X to node Y.

Figure 3: LFA inequality definition when forwarding address in non-zero

#### [3.2.6.2.](#) ASBRs advertising type1 and type2 cost



Link-Protection:

$$D_{\text{opt}}(N, PO\_i) + \text{cost}(PO\_i, P) < D_{\text{opt}}(N, S) + D_{\text{opt}}(S, PO\_best) + \text{cost}(PO\_best, P)$$

Link-Protection + Downstream-paths-only:

$$D_{\text{opt}}(N, PO\_i) + \text{cost}(PO\_i, P) < D_{\text{opt}}(S, PO\_best) + \text{cost}(PO\_best, P)$$

Node-Protection:

$$D_{\text{opt}}(N, PO\_i) + \text{cost}(PO\_i, P) < D_{\text{opt}}(N, E) + D_{\text{opt}}(E, PO\_best) + \text{cost}(PO\_best, P)$$

Where,

- S                - The computing router
- N                - The alternate router being evaluated
- E                - The primary next-hop on shortest path from S to prefix P.
- PO\_i            - The specific prefix-originating router being evaluated.
- PO\_best        - The prefix-originating router on the shortest path from the computing router S to prefix P.
- cost(X,Y)      - External cost for Y as advertised by X.
- D\_opt(X,Y)     - Distance on the shortest path from node X to node Y.

Figure 4: LFA inequality definition for type1 and type 2 cost

#### **4. Acknowledgements**

Thanks to Alia Atlas and Salih K A for their useful feedback and inputs.

#### **5. IANA Considerations**

N/A. - No protocol changes are proposed in this document.

#### **6. Security Considerations**

This document does not introduce any change in any of the protocol specifications. It simply proposes additional inequalities for selecting LFAs for multi-homed prefixes.

#### **7. References**



### **7.1. Normative References**

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

### **7.2. Informative References**

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

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