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Efficient Implementation Method for Loop-free Criterion
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Abstract

[RFC5286] introduces Loop-Free Criterion (LFC) in detail, which is a technology for local fast rerouting when network failures occur. With LFC, alternate next hops are stored alongside with the default next hops in a routers forwarding table, and can be immediately activated to invoke a loop free repair path in face of link failure. As long as not introducing routing loops, these alternative next hops can also be used for multipath transmission if there are stringent demands on bandwidth or load balancing. However, in such link state networks, computing loop free alternates typically requires one or more rounds of full shortest path tree computation on a graph, and poses a heavy burden to both the processor load and the memory consumption of a network equipment. In this document, we describe an efficient Loop-free Criterion (LFC) implementation method which is based on incremental shortest path first (i-SPF), which is suitable for practical deployment in large scale networks. The computational complexity of the method is independent of the average node degree of the network.

Status of This Memo

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Table of Contents

1. Introduction

Existing algorithms for computing LFC rely on one or more rounds of full shortest path tree computation on a graph, and cannot achieve both good coverage of alternates and low computational complexity at the same time. Based on graph properties we newly find, this document propose Incremental Alternates Computation IAC, which can compute the full set of alternates for a given network topology in a highly efficient way. IAC performs incremental shortest path computation on specific link cost update, where the sign of some cost is simply reversed.

2. Terminology

In this document, we employ OSPF as an example to explain our method. Each router in a single routing area maintains an identical network

map which allows them to compute the shortest path to every other router in a routing area. Then each router construct its FIB table employing the above information. When a packet arrives at a router, a destination address based method is using to determine how to forward the packets to its corresponding interface. When the network

topology changes, the routers adjacent to the changed component detects the change and then propagates the information to its neighboring router through the LSA (link state advertisement) information. After a period of time, all routers in this routing area are aware of the change information and update their routing tables accordingly, then the network is at a stable state.

LFC: x can be chosen when C(x,d) is lower than C(x,c)+C(c,d), which means when packets are routed from x to d, they will not be routed back to c, since C(x,c) + C(c,d) is the lowest cost of any path from x to d that passes c. So the protection route will bypass c, thus bypass link (c,b) too.

In order to implement LFC rule, each node needs to obtain costs for its neighbors as well as itself. With a linkstate protocol, it requires multiple shortest-path computations. In this document, the notation C(x,d) refers to the shortest path cost from node x to node d, x refers to the neighboring node of node c. w(c,x) refers to the weight of link (c,x), Tc refers to the shortest path tree rooted at node c, Tc(c,x) refers to the shortest path tree rooted at node c when the weight of the link (c,x) is changed to -w(c,x), D(Tc,x) refers to the descendants of node x (x is included) in the Tc, D(Tc(c,x),x) refers to the descendants of node x (x is included) in the Tc(c,x).

3. Overview of Solution

In general, in order to compute the LFCs set for a spcific destination d, a router needs to know the following information:

(1) the shortest path cost from the calculating router, for example router c, to the destination d (C(c,d)).

(2) the shortest path cost from the neighboring node x of c to the destination d (C(x,d)).

(3) the shortest path cost from the neighboring node x of c to itself (C(x,c)).

C(c,d) can be obtained from the shortest path tree Tc, C(x,c) is equal to w(x,c) which can be obtained from OSPF protocol, C(x,c) can be obtained by performing additional SPF calculations. Therefore, the induced cost will be particularly high for high degree nodes.

This document describes how to efficiently implement LFC rule on backbone networks. In order to implement LFC efficiently, the next hop computation rule is proposed.

Next hop computation rule:

For a node d, if d is not in the set of D(Tc,x), while d is in the set of D(Tc(c,x),x), we can get the node x is a valid next hop from c to d.

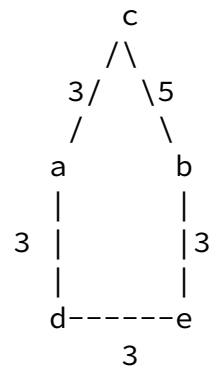

Figure 1: Network Topology

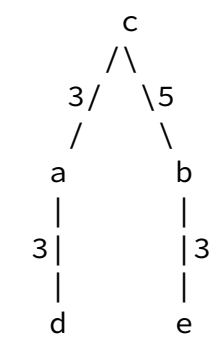

Figure 2: Shortest path first rooted at node c

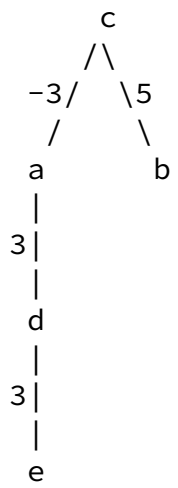

Figure 3: Shortest path first rooted at node c when the weight of link (c,a) is changed to -3

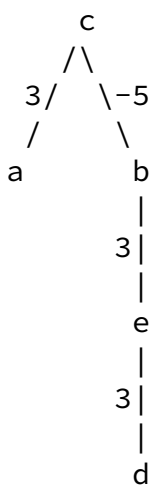

Figure 4: Shortest path first rooted at node c when the weight of link (c,b) is changed to -5

IAC cleverly uses Next hop computation rule, so it can realize LFC efficiently. IAC is suitable for incremental deployment within a network, including a network that is already deploying iSPF. We will use the following example to explain how ICA works. Fig. 1 depicts a network topology consisting of 5 nodes and 6 edges, while the

corresponding SPT Tc is depicted in Fig. 2(b), with c being the root. Fig. 3 shows the shortest path tree constructed using i-SPF when the weight of link (c,a) is changed to -3. Fig. 4 is the shortest path tree constructed using i-SPF when the weight of link (c,b) is changed to -5. We can see that node a can be a viable backup next-hop from c to e according to the next hop computation rule. We can get that node b can be a viable backup next-hop from c to d in the same way.

4. Security Considerations

The security considerations of [RFC5286] also apply.

5. Conclusions

The purpose of this document is to describe an efficient way to implement LFC, which can compute the full set of alternates with incremental shortest path first computation on specific link cost update. Therefore, IAC is suitable for deploying in the larger scale networks.

6. Normative References

[RFC5286] Atlas, A., Ed. and A. Zinin, Ed., "Basic Specification for IP Fast Reroute: Loop-Free Alternates", RFC 5286, DOI 10.17487/RFC5286, September 2008, <https://www.rfc-editor.org/info/rfc5286>.

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