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Using a Link State Advertisement (LSA) Options Bit to Prevent Looping in BGP/MPLS IP Virtual Private Networks (VPNs)

Status of This Memo

This document specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" (STD 1) for the standardization state and status of this protocol. Distribution of this memo is unlimited.

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Abstract

This document specifies a procedure that deals with a particular issue that may arise when a Service Provider (SP) provides "BGP/MPLS IP VPN" service to a customer and the customer uses OSPFv2 to advertise its routes to the SP. In this situation, a Customer Edge (CE) Router and a Provider Edge (PE) Router are OSPF peers, and customer routes are sent via OSPFv2 from the CE to the PE. The customer routes are converted into BGP routes, and BGP carries them across the backbone to other PE routers. The routes are then converted back to OSPF routes sent via OSPF to other CE routers. As a result of this conversion, some of the information needed to prevent loops may be lost. A procedure is needed to ensure that once a route is sent from a PE to a CE, the route will be ignored by any PE that receives it back from a CE. This document specifies the necessary procedure, using one of the options bits in the LSA (Link State Advertisements) to indicate that an LSA has already been forwarded by a PE and should be ignored by any other PEs that see it.

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1. Introduction

[VPN] describes a method by which a Service Provider (SP) can use its IP backbone to provide an "IP VPN" service to customers. In that sort of service, a customer's edge devices (CE devices) are connected to the provider's edge routers (PE routers). Each CE device is in a single Virtual Private Network (VPN). Each PE device may attach to multiple CEs of the same or of different VPNs. A VPN thus consists of a set of "network segments" connected by the SP's backbone.

A CE exchanges routes with a PE, using a routing protocol to which the customer and the SP jointly agree. The PE runs that routing protocol's decision process (i.e., it performs the routing computation) to determine the set of IP address prefixes for which the following two conditions hold:

- Each address prefix in the set can be reached via that CE.

- The path from that CE to each such address prefix does NOT include the SP backbone (i.e., it does not include any PE routers).

The PE routers that attach to a particular VPN redistribute routes to these address prefixes into BGP, so that they can use BGP to distribute the VPN's routes to each other. BGP carries these routes in the "VPN-IPv4 address family", so that they are distinct from ordinary Internet routes. The VPN-IPv4 address family also extends the IP addresses on the left so that address prefixes from two different VPNs are always distinct to BGP, even if both VPNs use the same piece of the private RFC 1918 address space. Thus, routes from different VPNs can be carried by a single BGP instance and can be stored in a common BGP table without fear of conflict.

If a PE router receives a particular VPN-IPv4 route via BGP, and if that PE is attached to a CE in the VPN to which the route belongs, then BGP's decision process may install that route in the BGP route table. If so, the PE translates the route back into an IP route and

redistributes it to the routing protocol that is running on the link to that CE.

This methodology provides a "peer model". CE routers peer with PE routers, but CE routers at different sites do not peer with each other.

If a VPN uses OSPFv2 as its internal routing protocol, it is not necessarily the case that the CE routers of that VPN use OSPFv2 to peer with the PE routers. Each site in a VPN can use OSPFv2 as its intra-site routing protocol while using BGP or RIP (for example) to distribute routes to a PE router. However, it is certainly convenient when OSPFv2 is being used intra-site to use it on the PE-CE link as well, and [VPN] explicitly allows this. In this case, a PE will run a separate instance of OSPFv2 for each VPN that is attached to the PE; the PE will in general have multiple VPN-specific OSPFv2 routing tables.

When OSPFv2 is used on a PE-CE link that belongs to a particular VPN, the PE router must redistribute to that VPN's OSPFv2 instance certain routes that have been installed in the BGP routing table. Similarly, a PE router must redistribute to BGP routes that have been installed in the VPN-specific OSPF routing tables. Procedures for this are specified in [VPN-OSPF].

The routes that are redistributed from BGP to OSPFv2 are advertised in LSAs that are originated by the PE. The PE acts as an OSPF border router, advertising some of these routes in AS-external LSAs, and some in summary LSAs, as specified in [VPN-OSPF].

Similarly, when a PE router receives an LSA from a CE router, it runs the OSPF routing computation. Any route that gets installed in the OSPF routing table must be translated into a VPN-IPv4 route and then redistributed into BGP. BGP will then distribute these routes to the other PE routers.

2. Specification of Requirements

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 RFC 2119.

3. Information Loss and Loops

A PE, say PE1, may learn a route to a particular VPN-IPv4 address prefix via BGP. This may cause it to generate a summary LSA or an AS-external LSA in which it reports that address prefix. This LSA may then be distributed to a particular CE, say CE1. The LSA may

then be distributed throughout a particular OSPF area, reaching another CE, say CE2. CE2 may then distribute the LSA to another PE, say PE2.

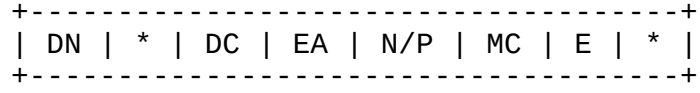
As stated in the previous section, PE2 must run the OSPF routing computation to determine whether a particular address prefix, reported in an LSA from CE2, is reachable from CE2 via a path that does not include any PE router. Unfortunately, there is no standard way to do this. The OSPFv2 LSAs do not necessarily carry the information needed to enable PE2 to determine that the path to address prefix X in a particular LSA from CE2 is actually a path that includes, say PE1. If PE2 then leaks X into BGP as a VPN-IPv4 route, then PE2 is violating one of the constraints for loop-freedom in BGP; viz., that routes learned from a particular BGP domain are not redistributed back into that BGP domain. This could cause a routing loop to be created.

It is therefore necessary to have a means by which an LSA may carry the information that a particular address prefix has been learned from a PE router. Any PE router that receives an LSA with this information would omit the information in this LSA from its OSPF routing computation, and thus it would not leak the information back into BGP.

When a PE generates an AS-external LSA, it could use a distinct tag value to indicate that the LSA is carrying information about an address prefix for whom the path includes a PE router. However, this method is not available in the case where the PE generates a Summary LSA. Per [VPN-OSPF], each PE router must function as an OSPF area 0 router. If the PE-CE link is an area 0 link, then it is possible for the PE to receive, over that link, a summary LSA that originated at another PE router. Thus, we need some way of marking a summary LSA to indicate that it is carrying information about a path via a PE router.

4. Using the LSA Options to Prevent Loops

The high-order bit of the LSA Options field (a previously unused bit) is used to solve the problem described in the previous section. We refer to this bit as the DN bit. When a type 3, 5, or 7 LSA is sent from a PE to a CE, the DN bit MUST be set. The DN bit MUST be clear in all other LSA types.



Options Field with DN Bit
(RFC 2328, Section A.2)

When the PE receives, from a CE router, a type 3, 5, or 7 LSA with the DN bit set, the information from that LSA MUST NOT be used during the OSPF route calculation. As a result, the LSA is not translated into a BGP route. The DN bit MUST be ignored in all other LSA types.

This prevents routes learned via BGP from being redistributed to BGP. (This restriction is analogous to the usual OSPF restriction that inter-area routes that are learned from area 0 are not passed back to area 0.)

Note that the DN bit has no other effect on LSA handling. In particular, an LSA with the DN bit set will be put in the topological database, aged, flooded, etc., just as if DN were not set.

5. Security Considerations

An attacker may cause the DN bit to be set, in an LSA traveling from CE to PE, when the DN bit should really be clear. This may cause the address prefixes mentioned in that LSA to be unreachable from other sites of the VPN. Similarly, an attacker may cause the DN bit to be clear, in an LSA traveling in either direction, when the DN bit should really be set. This may cause routing loops for traffic that is destined to the address prefixes mentioned in that LSA.

These possibilities may be eliminated by using cryptographic authentication as specified in Section D of [OSPFv2].

6. Acknowledgements

The idea of using the high-order options bit for this purpose is due to Derek Yeung. Thanks to Yakov Rekhter for his contribution to this work. We also wish to thank Acee Lindem for his helpful comments.

7. Normative References

[OSPFv2] Postel, J., "Suggested Telnet Protocol Changes", RFC 328, April 1972.

[VPN] Rosen, E. and Y. Rekhter, "BGP/MPLS IP Virtual Private Networks (VPNs)", RFC 4364, February 2006.

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