Inter-Domain Routing
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H. Gredler, Ed.
RtBrick Inc.
K. Vairavakkalai
C. Ramachandran
B. Rajagopalan
E. Aries
Juniper Networks, Inc.
L. Fang
eBay

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Egress Peer Engineering using BGP-LU
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Abstract

The MPLS source routing paradigm provides path control for both intra- and inter- Autonomous System (AS) traffic. RSVP-TE is utilized for intra-AS path control. This documents outlines how MPLS routers may use the BGP labeled unicast protocol (BGP-LU) for doing traffic-engineering on inter-AS links.

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 RFC 2119 [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 October 6, 2017.

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1. Introduction

Today, BGP-LU [RFC3107] is used both as an intra-AS [I-D.ietf-mpls-seamless-mpls] and inter-AS routing protocol. BGP-LU may advertise a MPLS transport path between IGP regions and Autonomous Systems. Those paths may span one or more router hops. This document describes advertisement and use of one-hop MPLS label-switched paths (LSPs) for traffic-engineering the links between Autonomous Systems.

Consider Figure 1: an ASBR router (R2) advertises a labeled host route for the remote-end IP address of its link (IP3). The BGP next-hop gets set to R2s loopback IP address. For the advertised Label <N> a forwarding action of 'POP and forward' to next-hop (IP3) is installed in R2's MPLS forwarding table. Now consider if R2 had several links and R2 would advertise labels for all of its inter-AS links. By pushing the corresponding MPLS label <N> on the label-stack an ingress router R1 may control the egress peer selection.

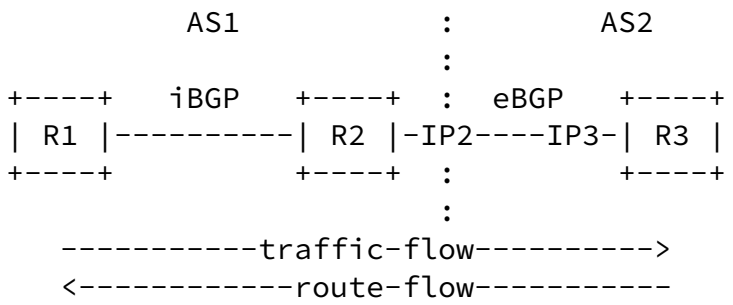


Figure 1: single-hop LSPs

Of course, since R1 and R2 may not be directly connected to each other, if the interior routers within AS1 do not maintain routes to external destinations, carrying traffic to such destinations would require a tunnel from R1 to R2. Such tunnel could be realized as either a MPLS Label Switched Path (LSP), or by GRE [RFC2784].

2. Motivation, Rationale and Applicability

BGP-LU is often just seen as a 'stitching' protocol for connecting Autonomous Systems. BGP-LU is often not viewed as a viable protocol for solving the Inter-domain traffic-engineering problem.

With this document the authors want to clarify the use of BGP-LU for Egress Peering traffic-engineering purposes and encourage both implementers and network operators to use a widely deployed and operationally well understood protocol, rather than inventing new protocols or new extensions to the existing protocols.

3. Sample Topology

The following topology (Figure 2) and IP addresses shall be used throughout the Egress Peering Engineering advertisement examples.

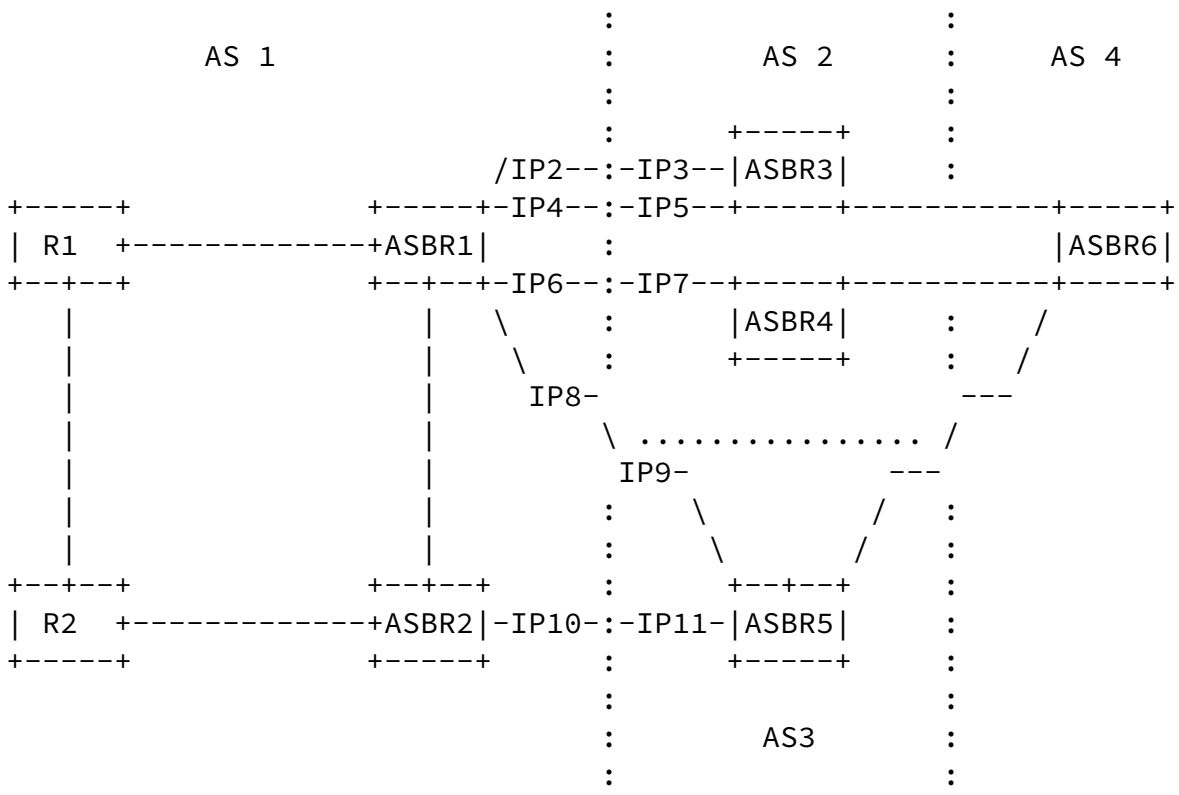


Figure 2: Sample Topology

3.1. Loopback IP addresses and Router-IDs

- R1: 192.0.2.1/32
- R2: 192.0.2.2/32
- ASBR1: 192.0.2.11/32
- ASBR2: 192.0.2.12/32
- ASBR3: 192.0.2.13/32
- ASBR4: 192.0.2.14/32
- ASBR5: 192.0.2.15/32
- ASBR6: 192.0.2.16/32

3.2. Link IP addresses

- ASBR1 (203.0.113.2/31) to ASBR3 (203.0.113.3/31) link #1
- ASBR1 (203.0.113.4/31) to ASBR3 (203.0.113.5/31) link #2
- ASBR1 (203.0.113.6/31) to ASBR4 (203.0.113.7/31)
- ASBR1 (203.0.113.8/31) to ASBR5 (203.0.113.9/31)
- ASBR2 (203.0.113.10/31) to ASBR5 (203.0.113.11/31)

4. Service Route Advertisement

In Figure 3 a simple network layout is shown. There are two classes of BGP speakers:

1. Ingress Routers
2. Controllers

Ingress routers receive BGP-LU routes from the ASBRs. Each BGP-LU

route corresponds to an egress link. Furthermore Ingress routers receive their service routes using the BGP protocol. The BGP Add-paths extension [I-D.ietf-idr-add-paths] ensures that multiple paths to a given service route may get advertised.

As outlined in [I-D.filsfils-spring-segment-routing-central-epe], Controllers receive BGP-LU routes from the ASBRs as well. However the service routes may be received either using the BGP protocol plus the BGP Add-paths extension [I-D.ietf-idr-add-paths] or alternatively The BGP Monitoring protocol [I-D.ietf-grow-bmp] (BMP). BMP has support for advertising the RIB-In of a BGP router. As such it might be a suitable protocol for feeding all potential egress paths of a service-route from a ASBR into a controller.

5. Egress Next-hop Advertisement

An ASBR assigns a distinct label for each of its next-hops facing an eBGP peer and advertises it to its internal BGP mesh. The ASBR programs a forwarding action 'POP and forward' into the MPLS forwarding table. Note that the neighboring AS is not required to support exchanging NLRIs with the local AS using BGP-LU. It is the local ASBR (ASBR{1,2}) which generates the BGP-LU routes into its iBGP mesh or controller facing session(s). The forwarding next-hop for those routes points to the link-IP addresses of the remote ASBRs (ASBR{3,4,5}). Note that the generated BGP-LU routes always match the BGP next-hop that the remote ASBRs set their BGP service routes

to, such that the software component doing route-resolution understands the association between the BGP service route and the BGP-LU forwarding route.

5.1. iBGP meshing and BGP nexthop rewrite policy

Throughout this document we describe how the BGP next-hop of both BGP Service Routes and BGP-LU routes shall be rewritten. This may clash with existing network deployments and existing network configurations guidelines which may mandate to rewrite the BGP next-hop when an BGP update enters an AS.

The Egress peering use case assumes a central controller as shown Figure 3. In order to support both existing BGP nexthop guidelines and the suggestion described in this document, an implementation

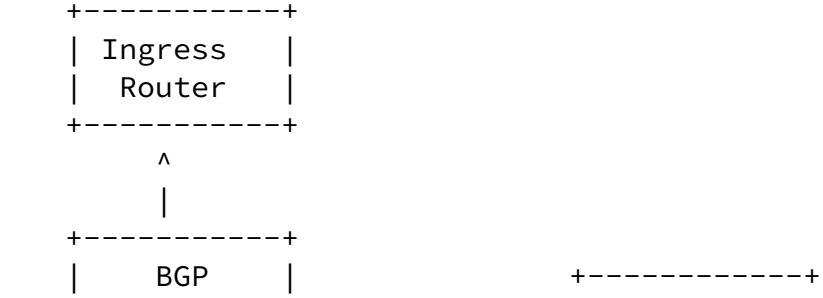
SHOULD support several internal BGP peer-groups:

1. iBGP peer group for Ingress Routers

2. iBGP peer group for Controllers

The first peer group MAY be left unchanged and use any existing BGP nexthop rewrite policy. The second peer group MUST use the BGP rewrite policy described in this document for both service and BGP-LU routes.

Of course a common iBGP peer group and a common rewrite policy may be used if the proposed policy is compatible with existing routing software implementations of BGP next-hop route resolution.



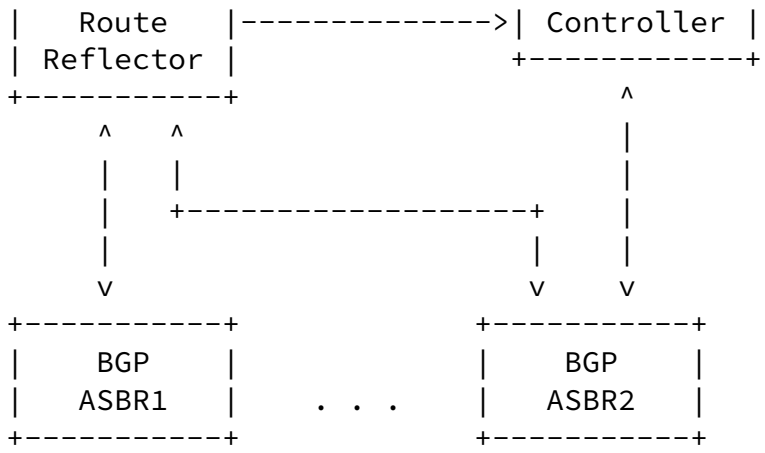


Figure 3: Selective iBGP NH rewrite

5.2. Single-hop eBGP

In Figure 2 the ASBR{1,5} and ASBR{2,5} links are examples for single-hop eBGP advertisements.

- ASBR5 advertises a BGP service (SAFI-1) route {172.16/12} to ASBR1 with a BGP next-hop of 203.0.113.9. When ASBR1 re-advertises this BGP service route towards its iBGP mesh (R{1,2}) it does not overwrite the BGP next-hop, but rather leaves it unchanged.

- ASBR1 advertises a BGP-LU route {203.0.113.9/32, label 100} with a BGP next hop of 192.0.2.11. ASBR1 programs a MPLS forwarding state of 'POP and forward' to 203.0.113.9 for the advertised label 100.

- ASBR5 advertises a BGP service (SAFI-1) route {172.16/12} to ASBR2 with a BGP next-hop of 203.0.113.11. When ASBR2 re-advertises this BGP service route towards its iBGP mesh (R{1,2}) it does not overwrite the BGP next-hop, but rather leaves it unchanged.

- ASBR2 advertises BGP-LU route {203.0.113.11/32, label 101} with a BGP next hop of 192.0.2.12. ASBR2 programs a MPLS forwarding state of 'POP and forward' to 203.0.113.11 for the advertised label 101.

- Should the operator already be redistributing egress links into

the network for purposes of BGP next-hop resolution, the BGP-LU route {203.0.113.9/32, label 100} will now take precedence due to LPM over the previous redistributed prefix {203.0.113.8/31}. If the BGP next-hop prefix {203.0.113.9/32} were to be redistributed as-is, then standard protocol best-path and preference selection mechanisms will be exhausted in order to select the best-path.

- In general, ASBR1 may receive advertisements for the route to 172.16/12 from ASBR3 and ASBR4, as well as from ASBR5. One of these other advertisements may be chosen as the best path by the BGP decision process. In order to allow ASBR1 to re-advertise the route to 172.16/12 received from ASBR5 with next-hop 203.0.113.9, independent of the other advertisements received, ASBR1 and R{1,2} need to support the BGP add-paths extension. [I-D.ietf-idr-add-paths].

5.3. Multi-hop eBGP

Todays operational practice for load-sharing across parallel links is to configure a single multi-hop eBGP session between a pair of routers. The IP addresses for the Multi-hop eBGP session are typically sourced from the loopback IP interfaces. Note that those IP addresses do not share an IP subnet. Most often those loopback IP addresses are most specific host routes. Since the BGP next-hops of the received BGP service routes are typically rewritten to the remote routers loopback IP address they cannot get immediatly resolved by the receiving router. To overcome this, the operator configures a static route with next-hops pointing to each of the remote-IP addresses of the underlying links.

In Figure 2 both ASBR{1,3} links are examples of a multi-hop eBGP advertisement. In order to advertise a distinct label for a common FEC throughout the iBGP mesh, ASBR1 and all the receiving iBGP routers need to support the BGP Add-paths extension. [I-D.ietf-idr-add-paths].

- ASBR3 advertises a BGP service (SAFI-1) route {172.16/12} over multi-hop eBGP to ASBR1 with a BGP next-hop of 192.0.2.13. When ASBR1 re-advertises this BGP service route towards its iBGP mesh (R{1,2}) it does not overwrite the BGP next-hop, but rather leaves it unchanged. Note that the iBGP routers SHOULD support the BGP Add-paths extension [I-D.ietf-idr-add-paths] such that ASBR can re-advertise all paths to the SAFI-1 route {172.16/12}.

- For link #1, ASBR1 advertises into its iBGP mesh a BGP-LU route {192.0.2.13/32, label 102} with a BGP next hop of 192.0.2.11. To differentiate this from the link #2 route-advertisement (which

contains the same FEC) it is setting the path-ID to 1. ASBR1 programs a MPLS forwarding state of 'POP and forward' to 203.0.113.3 for the advertised label 102.

- For link #2, ASBR1 advertises into its iBGP mesh a BGP-LU route {192.0.2.13/32, label 103} with a BGP next hop of 192.0.2.11. To differentiate this from the link #1 route-advertisement (which contains the same FEC) it is setting the path-ID to 2. ASBR1 programs a MPLS forwarding state of 'POP and forward' to 203.0.113.5 for the advertised label 103.

- Should the operator already be redistributing static routes into the network, the BGP next-hop {192.0.2.13} may already be resolvable. It is then that standard protocol best-path and preference selection mechanisms will be exhausted in order to select the best-path.

5.4. Grouping of Peers

In addition to offering a distinct BGP-LU label for each egress link, an ASBR MAY want to advertise a BGP-LU label which represents a load-balancing forwarding action across a set of peers. The difference is here that the ingress node gives up individual link control, but rather delegates the load-balancing decision to a particular egress router which has the freedom to send the traffic down to any link in the Peer Set as identified by the BGP-LU label.

Assume that ASBR1 wants to advertise a label identifying the Peer Set {ASBR3, ASBR4, ASBR5}.

- For the two ASBR{1,3} links in Figure 2, belonging to Peer Set 1, ASBR1 advertises a single BGP-LU route {192.0.2.13/32, label 104} with a BGP next hop of 192.0.2.11. To differentiate this from the ASBR{1,3} single link route-advertisements (which contains the same FEC) it is setting the path-ID to 3 and attaching a Peer-Set Community 'Peer Set 1'.

- For the ASBR{1,4} link in Figure 2, ASBR1 advertises a BGP-LU route {203.0.113.7/32, label 104} with a BGP next hop of 192.0.2.11. To differentiate this from the ASBR{1,4} single link route-advertisements (which contains the same FEC) it is setting the path-ID to 2 and attaching a Peer-Set Community 'Peer Set 1'.

- For the ASBR{1,5} link in Figure 2, ASBR1 advertises a BGP-LU route {203.0.113.9/32, label 104} with a BGP next hop of 192.0.2.11. To differentiate this from the ASBR{1,5} single link

route-advertisements (which contains the same FEC) it is setting the path-ID to 2 and attaching a Peer-Set Community 'Peer Set 1'.

Finally ASBR1 programs a MPLS forwarding state of 'POP and load-balance' to {203.0.113.3, 203.0.113.5, 203.0.113.7, 203.0.113.9} for the advertised label 104.

5.5. Supporting Summarization at ASBR

5.5.1. Locality forwarding bias

A router has one or more forwarding plane units. A forwarding plane unit consists of one or more interfaces. Forwarding of packets to an interface that is member of a forwarding plane unit is cheaper than across units.

A route entry in the forwarding-table may contain multiple next-hops, each pointing to a network-interface. When forwarding a packet, a forwarding plane unit may optionally provide preference to a subset of these next-hops, whose interfaces are its own members. This behavior is called "Locality forwarding bias".

5.5.2. Label per group of peers sharing a locality

An ASBR MAY assign a distinct label for the set of eBGP-peers that share a forwarding plane unit and advertise it to its internal BGP mesh. The ASBR programs a forwarding action 'POP and IP-lookup' into the MPLS forwarding table for these labels. While performing the IP-lookup, the ASBR MUST perform "Locality-forwarding bias" to ensure it only selects next-hops towards eBGP peers that are attached to the current forwarding plane unit, where the IP-lookup is happening.

This provides the ingress-peers with ability to steer traffic towards a "subset of eBGP-peers" attached to an ASBR, while preserving the ability of the ASBR to aggregate the IP prefixes received from those eBGP-peers, while re-advertising to the internal BGP mesh.

6. Egress Link Protection

It is desirable to provide a local-repair based protection scheme, in case a redundant path is available to reach a peer AS. Protection may be applied at multiple levels in the routing stack. Since the

ASBR has insight into both BGP-LU and BGP service advertisements, protection can be provided at the BGP-LU, at the BGP service or both levels.

6.1. FRR backup routes

Assume the network operator wants to provide a local-repair next-hop for the 172.16/12 BGP service route at ASBR1. The active route resolves over the parallel links towards ASBR3. In case the link #1

between ASBR{1,3} fails there are now several candidate backup paths providing protection against link or node failure.

6.1.1. Local links

Assuming that the remaining link #2 between ASBR{1,3} has enough capacity, and link-protection is sufficient, this link MAY serve as temporary backup.

However if node-protection or additional capacity is desired, then the local link between ASBR{1,4} or ASBR{1,5} MAY be used as temporary backup.

6.1.2. Remote BGP-LU labels

ASBR1 is both originator and receiver of BGP routing information. For this protection method it is required that the ASBRs support the [I-D.ietf-idr-best-external] behavior. ASBR1 receives both the BGP-LU and BGP service routes from ASBR2 and therefore can use the ASBR2 advertised label as a backup path given that ASBR1 has a tunnel towards ASBR2.

6.1.3. Local IP forwarding tables

For protecting plain unicast (Internet) routing information a very simple backup scheme could be to recurse to the relevant IP forwarding table and do an IP lookup to further determine a new egress link.

7. Dynamic link utilization

For a software component which controls the egress link selection it

may be desirable to know about a particular egress links current utilization, such that it can adjust the traffic that gets sent to a particular interface.

In [I-D.ietf-idr-link-bandwidth] a community for reporting link-bandwidth is specified. Rather than reporting the static bandwidth of the link, the ASBRs shall report the available bandwidth as seen by the data-plane via the link-bandwidth community in their BGP-LU update message.

It is crucial that ingress routers learn quickly about congestion of an egress link and hence it is desired to get timely updates of the advertised per-link BGP-LU routes carrying the available bandwidth information when the available bandwidth crosses a certain (preconfigured) threshold.

Controllers may also utilize the link-bandwidth community among other common mechanisms to retrieve data-plane statistics (e.g. SNMP, NETCONF)

8. Acknowledgements

Many thanks to Yakov Rekhter, Chris Bowers and Jeffrey (Zhaohui) Zhang for their detailed review and insightful comments.

Special thanks to Richard Steenbergen and Tom Scholl who brought up the original idea of using MPLS for BGP based egress load-balancing at their inspiring talk at Nanog 48.

9. IANA Considerations

This documents does not request any action from IANA.

10. Security Considerations

This document does not introduce any change in terms of BGP security.

11. References

11.1. Normative References

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Authors' Addresses

Hannes Gredler (editor)
RtBrick Inc.

Email: hannes@rtbrick.com

Kaliraj Vairavakkalai
Juniper Networks, Inc.
1194 N. Mathilda Ave.
Sunnyvale, CA 94089
US

Email: kaliraj@juniper.net

Chandra Ramachandran
Juniper Networks, Inc.
Electra, Exora Business Park Marathahalli - Sarjapur Outer Ring Road
Bangalore, KA 560103
India

Email: csekar@juniper.net

Balaji Rajagopalan
Juniper Networks, Inc.

Electra, Exora Business Park Marathahalli - Sarjapur Outer Ring Road
Bangalore, KA 560103
India

Email: balajir@juniper.net

Ebben Aries
Juniper Networks, Inc.
1194 N. Mathilda Ave.
Sunnyvale, CA 94089
US

Email: earies@juniper.net

Luyuan Fang
eBay
411 108th Ave NE
Bellevue, WA 98004
US

Email: lufang@ebay.com