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Use of BGP Large Communities

Abstract

This document presents examples and inspiration for operator application of BGP Large Communities. Based on operational experience with BGP Communities, this document suggests logical categories of BGP Large Communities and demonstrates an orderly manner of organizing community values within them to achieve typical goals in routing policy. Any operator can consider using the concepts presented as the basis for their own BGP Large Communities repertoire.

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1. Introduction

BGP Large Communities [RFC8092] provide a mechanism to signal opaque information between and within Autonomous Systems (ASes). In very much the same way that [RFC1998] provides a concrete real-world application for BGP Communities [RFC1997], this document presents examples of how operators might utilize BGP Large Communities to achieve various goals. This document draws on the experience of operator communities such as the North American Network Operators' Group (NANOG) <https://www.nanog.org/> and the Netherlands Network Operator Group (NLNOG) <https://nlnog.net/>.

2. The Design Overview

BGP Large Communities are composed of three 4-octet fields. The first is the Global Administrator (GA) field, whose value is the Autonomous System Number (ASN) of the AS that has defined the meaning of the remaining two 4-octet fields, known as "Local Data Part 1" and "Local Data Part 2". This document describes an approach where the "Local Data Part 1" field contains a function identifier and the "Local Data Part 2" contains a parameter value. Using the canonical notation this format can be summarized as "ASN:Function:Parameter".

RFC 8092	this document
Global Administrator	ASN
Local Data Part 1	Function
Local Data Part 2	Parameter

Table 1: Field Mapping

The table above shows a mapping table between the fields in BGP Large Communities [RFC8092] and this document.

In contemporary deployments of both BGP Communities [RFC1997] and BGP Large Communities [RFC8092], the function of a community can be divided into two categories:

- o Informational Communities

- o Action Communities

Throughout the document, a topology of four ASes is used to illustrate the use of communities in the following configuration:

```
           AS 65551
               |
               ^
               |
           AS 64497
             /  \
            ^    \
           /      ^
      AS 64498     \
          |         |
          `<->- AS 64499
```

AS 64497 obtains transit services from (is a customer of) AS 65551, a 4-octet ASN. AS 64497 provides transit services to both AS 64498 and AS 64499. AS 64498 and AS 64499 maintain a peering relationship in which they only exchange their customer routes.

The opaque nature of BGP Large Communities allows for rapid deployment of new features or changes to their routing policy that perform an action. Operators are encouraged to publicly publish and maintain documentation on the purpose of each BGP Large Community, both Informational and Action, that they support or that are visible in BGP RIBs.

2.1. Informational Communities

Informational Communities are labels for attributes such as the origin of the route announcement, the nature of the relation with an External BGP (EBGP) neighbor, or the intended propagation audience. Informational Communities can also assist in providing valuable information for day-to-day network operations such as debugging or capacity planning.

The Global Administrator field is set to the ASN of the network that tags the routes with the Informational Communities. For example, AS 64497 might add a community with the GA 64497 to a route accepted from an Internal BGP (IBGP) or EBGP neighbor as a means of signaling that it was imported in a certain geographical region.

In general, the intended audiences of Informational Communities are downstream networks and the GA itself, but any AS could benefit from receiving these communities.

2.2. Action Communities

Action Communities are added as labels to request that a route be treated in a particular way within an AS. The operator of the AS defines a routing policy that adjusts path attributes based on the community. For example, the route's propagation characteristics, the LOCAL_PREF (local preference), the next hop, or the number of AS_PATH prepends to be added when it is received or propagated can be changed.

The Global Administrator field is set to the ASN that has defined the functionality of that BGP Large Community and is the ASN that is expected to perform the action. For example, AS 64499 might label a route with a BGP Large Community containing GA 64497 to request that AS 64497 perform a predefined action on that route.

In general, the intended audience of Action Communities are transit providers taking action on behalf of a customer or the GA itself, but any AS could take action if they choose and any AS could add an Action Community with the GA of a non-adjacent ASN. However, note that an Action Community could also be Informational. Its presence is an indicator that the GA may have performed the action and that an AS in the AS_PATH requested it.

Operators are recommended to publish the relative order in which Action Communities (both BGP Communities and BGP Large Communities) are processed in their routing policy.

3. Examples of Informational Communities

3.1. Location

An AS, AS 64497 in these examples, may inform other networks about the geographical region where AS 64497 imported a route by labeling it with BGP Large Communities following one of the following schemes or a combination of them.

3.1.1. An ISO 3166-1 Numeric Function

AS 64497 could assign a value of 1 to the Function field to designate the content of the Parameter field as an ISO 3166-1 numeric country identifier <https://www.iso.org/iso-3166-country-codes.html>.

BGP Large Community	Description
64497:1:528	Route learned in the Netherlands
64497:1:392	Route learned in Japan
64497:1:840	Route learned in the United States of America

Table 2: Informational: ISO 3166-1

The table above shows example documentation for Informational Communities deployed by AS 64497 to describe the location where a route was imported using ISO 3166-1 numeric identifiers.

3.1.2. A UN M.49 Region Function

AS 64497 could assign a value of 2 to the Function field to designate the content of the Parameter field as the M.49 numeric code published by the United Nations Statistics Division (UNSD) <https://unstats.un.org/unsd/methodology/m49/> for macro-geographical (continental) regions, geographical sub-regions, or selected economic and other groupings.

BGP Large Community	Description
64497:2:2	Route learned in Africa
64497:2:9	Route learned in Oceania
64497:2:145	Route learned in Western Asia
64497:2:150	Route learned in Europe

Table 3: Informational: UNSD Regions

The table above shows example documentation for Informational Communities deployed by AS 64497 to describe the location where a route was imported using M.49 numeric codes published by the UNSD.

3.2. Relation Function

An AS, AS 64497 in this example, could assign a value of 3 to the Function field to designate the content of the Parameter field as a number indicating whether the route originated inside its own network or was learned externally, and if learned externally, it might simultaneously characterize the nature of the relation with that specific EBGP neighbor.

BGP Large Community	Description
64497:3:1	Route originated internally
64497:3:2	Route learned from a customer
64497:3:3	Route learned from a peering partner
64497:3:4	Route learned from a transit provider

Table 4: Informational: Relation

The table above shows example documentation for Informational Communities deployed by AS 64497 to describe the relation to the ASN from which the route was learned.

3.3. Combining Informational Communities

A route may be labeled with multiple Informational Communities. For example, a route learned in the Netherlands from a customer might be labeled with communities 64497:1:528, 64497:2:150, and 64497:3:2 at the same time.

4. Examples of Action Communities

4.1. Selective NO_EXPORT

As part of an agreement, often a commercial transit agreement, between AS 64497 and AS 64498, AS 64497 might expose BGP traffic-engineering functions to AS 64498. One such BGP traffic-engineering function could be selective NO_EXPORT, which is the selective filtering of a route learned from one AS, AS 64498, to certain EBGP neighbors of the GA, AS 64497.

4.1.1. ASN-Based Selective NO_EXPORT

AS 64497 could assign a value of 4 to the Function field to designate the content of the Parameter field as a neighboring ASN to which a route should not be propagated.

BGP Large Community	Description
64497:4:64498	Do not export route to AS 64498
64497:4:64499	Do not export route to AS 64499
64497:4:65551	Do not export route to AS 65551

Table 5: Action: ASN NO_EXPORT

The table above shows example documentation for Action Communities deployed by AS 64497 to expose a BGP traffic-engineering function that selectively prevents the propagation of routes to the neighboring ASN specified in the Parameter field.

4.1.2. Location-Based Selective NO_EXPORT

AS 64497 could assign a value of 5 to the Function field to designate the content of the Parameter field as an ISO 3166-1 numeric country identifier within which a labeled route is not propagated to EBGP neighbors. However, this might not prevent one of those EBGP neighbors from learning that route in another country and making it available in the country specified by the BGP Large Community.

BGP Large Community	Description
64497:5:528	Do not export to EBGP neighbors in the Netherlands
64497:5:392	Do not export to EBGP neighbors in Japan
64497:5:840	Do not export to EBGP neighbors in the United States of America

Table 6: Action: NO_EXPORT in Region

The table above shows example documentation for Action Communities deployed by AS 64497 to expose a BGP traffic-engineering function that selectively prevents the propagation of routes to all EBGP neighbors in the geographical region specified in the Parameter field.

4.2. Selective AS_PATH Prepending

As part of an agreement between AS 64497 and AS 64498, AS 64497 might expose BGP traffic-engineering functions to AS 64498. One such BGP traffic-engineering function could be selective prepending of the AS_PATH with AS 64497 to certain EBGP neighbors of AS 64497.

4.2.1. ASN-Based Selective AS_PATH Prepending

AS 64497 could assign a value of 6 to the Function field to designate the content of the Parameter field as a neighboring ASN to which prepending of the AS_PATH with AS 64497 is requested on propagation of the route. Additional AS_PATH prepending functions might also be defined to support multiples of prepending, that is, two, three, or more prepends of AS 64497.

BGP Large Community	Description
64497:6:64498	Prepend 64497 once on export to AS 64498
64497:6:64499	Prepend 64497 once on export to AS 64499
64497:6:65551	Prepend 64497 once on export to AS 65551

Table 7: Action: Prepend to ASN

The table above shows example documentation for Action Communities deployed by AS 64497 to expose a BGP traffic-engineering function that selectively prepends the AS_PATH with AS 64497 when propagating the route to the specified EBGP neighbor.

4.2.2. Location-Based Selective AS_PATH Prepending

AS 64497 could assign a value of 7 to the Function field to designate the content of the Parameter field as an ISO 3166-1 numeric country identifier to which the prepending of the AS_PATH with AS 64497 is requested on propagation of the route to all EBGP neighbors in that region.

BGP Large Community	Description
64497:7:528	Prepend once to EBGP neighbors in the Netherlands
64497:7:392	Prepend once to EBGP neighbors in Japan
64497:7:840	Prepend once to EBGP neighbors in the United States of America

Table 8: Action: Prepend in Region

The table above shows example documentation for Action Communities deployed by AS 64497 to expose a BGP traffic-engineering function that selectively prepends the AS_PATH with AS 64497 when propagating the route to all EBGP neighbors in the geographical region specified in the Parameter field.

4.3. Manipulation of the LOCAL_PREF Attribute

As part of an agreement between AS 64497 and AS 64498, AS 64497 might expose BGP traffic-engineering functions to AS 64498. One such BGP traffic-engineering function might allow AS 64498 to manipulate the value of the LOCAL_PREF attribute of routes learned from AS 64498 within AS 64497, even though the LOCAL_PREF attribute is non-transitive and is not propagated to EBGP neighbors.

The LOCAL_PREF value of routes are locally significant within each AS and are impossible to list in this document. Instead, the typical LOCAL_PREF values could be classified as a hierarchy, and a BGP Large Community function could be exposed, allowing an EBGP neighbor to affect the LOCAL_PREF value within the specified GA. The following example list defines the classes of routes in the order of descending LOCAL_PREF value and assigns a function identifier that could be used in the Function field of a BGP Large Community.

Function	Preference Class
8	Normal customer route
9	Backup customer route
10	Peering route
11	Upstream transit route
12	Fallback route, to be installed if no other path is available

Table 9: Action: Preference Function Identifiers

4.3.1. Global Manipulation of LOCAL_PREF

AS 64497 could place one of the previously defined Preference Function Identifiers in the Function field and set the value 0 in the Parameter field to designate that the LOCAL_PREF associated with that function identifier should be applied for that route throughout the whole AS.

BGP Large Community	Description
64497:9:0	Assign LOCAL_PREF for a customer backup route
64497:10:0	Assign LOCAL_PREF for a peering route
64497:12:0	Assign LOCAL_PREF for a fallback route

Table 10: Action: Global LOCAL_PREF Manipulation

The table above shows example documentation for Action Communities deployed by AS 64497 to expose a BGP traffic-engineering function that allows a BGP neighbor to globally manipulate the LOCAL_PREF attribute for the route within AS 64497.

4.3.2. Region-Based Manipulation of LOCAL_PREF

AS 64497 could place one of the previously defined Preference Function Identifiers in the Function field and use a UN M.49 numeric region identifier in the Parameter field to designate the geographical region within which the non-default LOCAL_PREF associated with that function identifier should be applied to the route. The value of the LOCAL_PREF attribute should not deviate from the default for that route class in any region not specified by one or more of these Action Communities.

BGP Large Community	Description
64497:9:3	Assign the LOCAL_PREF value equivalent to a customer backup class route on BGP routers in the North America region
64497:10:5	Assign the LOCAL_PREF value equivalent to a peering class route on BGP routers in the South America region
64497:12:142	Assign the LOCAL_PREF value equivalent to a fallback class route on BGP routers in the Asia region

Table 11: Action: Regional LOCAL_PREF Manipulation

The table above shows example documentation for Action Communities deployed by AS 64497 to expose a BGP traffic-engineering function that allows a BGP neighbor to selectively manipulate the LOCAL_PREF attribute within AS 64497 in the geographical region specified in the Parameter field.

4.3.3. Note of Caution for LOCAL_PREF Functions

The LOCAL_PREF attribute strongly influences the BGP Decision Process, which in turn affects the scope of route propagation. Operators should take special care when using Action Communities that decrease the LOCAL_PREF value, and the degree of preference, to a value below that of another route class. Some of the unintended BGP states that might arise as a result of these traffic-engineering decisions are described as "BGP Wedgies" in [RFC4264].

4.4. Route Server Prefix Distribution Control

Route servers [RFC7947] use BGP to broker network reachability information among their clients. As not all route server clients may wish to interconnect with each other, the route server operator will usually implement a mechanism to allow each client to control the route server's export routing policy, as described in Section 4.6 of [RFC7948]. One widely used mechanism is an adaption of "ASN-Based Selective NO_EXPORT" (Section 4.1.1) that is specific to route servers.

An example BGP Large Communities policy that enables client-controlled prefix distribution for a route server operating as AS 64511 is outlined as follows:

BGP Large Community	Description
64511:0:peer-as	Explicitly prevent announcement of route to peer-as
64511:1:peer-as	Explicitly announce route to peer-as
64511:0:0	Do not announce route to any peers by default
64511:1:0	Announce route to all peers by default

Table 12: Action: Route Server Prefix Distribution Control

Multiple BGP Large Community values can be used together to implement fine-grained route distribution control. For example, route server client AS 64500 might wish to use a route server for interconnecting to all other clients except AS 64509. In this case, they would label all their outbound routes to the route server with 64511:1:0 (to announce to all clients by default) and 64511:0:64509 (to prevent announcement to AS 64509).

Alternatively, route server client AS 64501 may have a selective routing policy and may wish to interconnect with only AS 64505 and AS 64506. This could be implemented by announcing routes labeled with 64511:0:0 (blocking all distribution by default) and 64511:1:64505, 64511:1:64506 to instruct the route server to force announcement to those two ASNs.

5. Security Considerations

Operators should note the recommendations in Section 11 of "BGP Operations and Security" [RFC7454] and handle BGP Large Communities with their ASN in the Global Administrator field similarly.

In particular and in the same respect as BGP Communities [RFC1997], operators should be cognizant that any Large Community can be carried in a BGP UPDATE. Operators should recognize that BGP neighbors, particularly customers and customers of customers, may utilize communities defined by other BGP neighbors of the operator. They may wish to send routes with Action Communities and receive routes with Informational Communities to or from these other neighbors, and it is beneficial to all to permit this.

6. IANA Considerations

This document does not require any IANA actions.

7. References

7.1. Normative References

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