Autonomous System (AS) Migration Features and Their Effects on the BGP AS_PATH Attribute
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Abstract

   This draft discusses common methods of managing an ASN migration
   using some BGP features that while commonly-used are not formally
   part of the BGP4 protocol specification and may be vendor-specific in
   exact implementation. It is necessary to document these de facto
   standards to ensure that they are properly supported in BGPSec.

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1. Introduction

   This draft discusses common methods of managing an ASN migration
   using some BGP features that while commonly-used are not formally
   part of the BGP4 [RFC4271] protocol specification and may be vendor-
   specific in exact implementation. This draft does not attempt to
   standardize these features, because they are local to given
   implementation and do not require negotiation with or cooperation of
   BGP neighbors. The deployment of these features do not need to
   interwork with one another to accomplish the desired results.
   However, it is necessary to document these de facto standards to
   ensure that any future protocol enhancements to BGP that propose to
   read, copy, manipulate or compare the AS_PATH attribute can do so
   without inhibiting the use of these very widely used ASN migration
   features.

   It is important to understand the business need for these features,
   as well, to illustrate why they are critical, particularly for ISP's
   operations. (It should be noted that these features are not limited
   to ISP's and that organizations of all sizes use these features for
   similar reasons to ISP's). During a merger, acquisition or
   divestiture involving two organizations it is necessary to seamlessly
   migrate BGP speakers from one ASN to a second ASN. The overall goal
   in doing so, particularly in the case of a merger or acquisition, is
   to achieve a uniform operational model through consistent
   configurations across all BGP speakers in the combined network. In
   addition, and perhaps more importantly, it is common practice in the
   industry for ISPs to bill customers based on utilization. ISPs bill
   customers based on the 95th percentile of the greater of the traffic
   sent or received, over the course of a 1-month period, on the
   customer's PE-CE access circuit. Given that the BGP Path Selection
   algorithm selects routes with the shortest AS_PATH attribute, it is
   critical for the ISP to not increase AS_PATH length during or after
   ASN migration, toward both downstream transit customers as well as
   settlement-free peers, who are likely sending or receiving traffic
   from those transit customers. This would not only result in sudden
   changes in traffic patterns in the network, but also (substantially)
   decrease utilization driven revenue at the ISP. It can also be bad
   for the end customers, as they may use AS prepends as a way to manage
   the AS_PATH to ensure optimal traffic engineering from their multiple
   upstream SPs, and a sudden change in the AS_PATH may cause an
   undesirable shift in traffic.

   Lastly, it is important to note that, by default, the BGP protocol
   requires an operator to configure a single remote ASN for the eBGP
   neighbor inside a router, in order to successfully negotiate and
   establish an eBGP session. Prior to the existence of these features,
   it would have required an ISP to work with, in some cases, tens of

thousands of customers. In particular, the ISP would have to
encourage those customers to change their CE router configs to use
the new ASN, in a very short period of time, when the customer has no
business incentive to do so. Thus, it because critical to allow the
ISP to seamlessly migrate the ASN within its network(s), not disturb
existing customers and allow the customer's to gradually migrate to
the ISP's new ASN at their leisure.

1.1. 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].

2. ASN Migration Scenario Overview

The use case being discussed here is an ISP merging two or more ASNs,
where eventually one ASN subsumes the other(s). In this use case, we
will assume the most common case where there are two ISPs, A and B,
that use AS 200 and 300, respectively, before the ASN migration is to
occur. AS 200 will be the "keep" ASN used across the consolidated
set of both ISPs' network equipment and AS 300 will be retired.
Thus, at the conclusion of the ASN migration, there will be a single
ISP A' with all internal BGP speakers configured to use AS 200. To
all external BGP speakers, the AS_PATH length will not be increased.

In this same scenario, AS 100 and AS 400 represent two, separate
customer networks: C and D, respectively. Originally, customer C (AS
100) is attached to ISP B, which will undergo ASN migration from AS
300 to AS 200. Furthermore, customer D (AS 100) is attached to ISP
A, which does not undergo ASN migration since ISP A's ASN will remain
constant, (AS 200). Although this example refers to AS 100 and 400
as customer networks, either or both may be settlement-free or other
types of peers. In this use case they are referred to as "customers"
merely for convenience.

The general order of operations, typically carried out in a single
maintenance window by the network undergoing ASN migration, ISP B,
are as follows. First, ISP B, will change the global BGP ASN used by
a PE router, from ASN 300 to 200. At this point, the router will no
longer be able to establish eBGP sessions toward the existing CE
devices that are attached to it and still using AS 300. Second, ISP
B will configure two separate, but related ASN migration features
discussed in this document on all eBGP sessions toward all CE
devices. These features modify the AS_PATH attribute received from
and transmitted toward CE devices to achieve the desired effect of
not increasing the length of the AS_PATH.

At the conclusion of the ASN migration, The subset of eBGP speakers, AS 400, that were formerly configured to establish a BGP session with ISP B's legacy AS 300 will still receive AS 300 in the AS_PATH received from ISP A'. To be clear, that same subset of CE devices, in AS 400, will not see the new AS 200 in the AS_PATH, until the time those CE devices have changed their configuration to establish an eBGP session to the new AS, AS 200.

In this use case, neither ISP is using BGP Confederations RFC 5065 [RFC5065] internally.

Additional information about this scenario, including vendor-specific implementation details can be found here: Cisco [CISCO] and here: Juniper [JUNIPER]. Equivalent features do exist in several implementations, however publicly available documentation is not available. Finally, the examples cited below use Cisco IOS CLI for ease of illustration purposes only.

3. Local AS: Modify Inbound BGP AS_PATH Attribute

ISP B needs to reconfigure its router(s) to participate as an internal BGP speaker in AS 200, to realize the business goal of becoming a single Service Provider: ISP A'. ISP B needs to do this without coordinating the change of its ASN with all of its eBGP peers, simultaneously. The first step is for ISP B to change the global AS in its router configuration, used by the local BGP process as the system-wide Autonomous System ID, from AS 300 to AS 200. The next step is for ISP B to establish iBGP sessions with ISP A's existing routers, thus consolidating ISP B into ISP A operating under a single AS: ISP A', (AS 200).

The next step is for ISP B to reconfigure its PE router(s) so that each of its eBGP sessions toward all eBGP speakers with a feature called "Local AS". This feature allows ISP B's PE router to re-establish an eBGP session toward the existing CE devices using the legacy AS, AS 300, in the eBGP session establishment. Ultimately, the CE devices, (i.e.: customer C), are completely unaware that ISP B has reconfigured its router to participate as a member of a new AS. Within the context of ISP B's PE router, the second effect this feature has is that, by default, it prepends all received BGP UPDATE's with the legacy AS of ISP B: AS 300. Thus, within ISP A' the AS_PATH toward customer C would appear as: 300 100, which is an increase in AS_PATH length from previously. Therefore, a secondary feature "No Prepend" is required to be added to the "Local AS" configuration toward every eBGP neighbor on ISP B's PE router. The "No Prepend" feature causes ISP B's PE router to not prepend the legacy AS, AS 300, on all received eBGP UPDATE's from customer C.
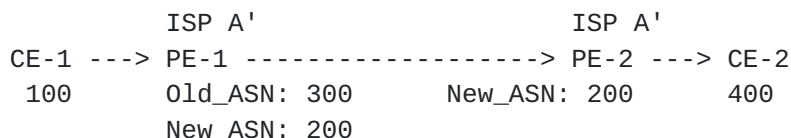
This restores the AS_PATH within ISP A' toward customer C so that it is just one AS long: 100.

In the direction of CE -> PE (inbound):

1. 'local-as <old_ASN>': appends the <old_ASN> value to the AS_PATH of routes received from the CE

2. 'local-as <old_ASN> no-prepend': does not prepend <old_ASN> value to the AS_PATH of routes received from the CE

As stated previously, local-as <old_ASN> no-prepend, (configuration #2), is critical because it does not increase the AS_PATH length. Ultimately, this ensures that routes learned from ISP B's legacy customers will be transmitted through legacy eBGP sessions of ISP A, toward both customers and peers, will contain only two ASes in the AS_PATH: 200 100. Thus, the legacy customers and peers of ISP A will not see an increase in the AS_PATH length to reach ISP B's legacy customers.

PE-1 is a PE that was originally in ISP B. PE-1 has had its global configuration AS changed from AS 300 to AS 200 to make it part of the permanently retained ASN. This now makes PE-1 a member of ISP A'. PE-2 is a PE that was originally in ISP A. Although its global configuration AS remains AS 200 throughout this exercise we also consider PE-2 a member of ISP A'.

```
                   ISP A'                      ISP A'
        CE-1 ---> PE-1 ------------------> PE-2 ---> CE-2
         100       Old_ASN: 300      New_ASN: 200      400
                   New_ASN: 200
```

Note: Direction of BGP UPDATE as per the arrows.

Figure 1: Local AS BGP UPDATE Diagram

The final configuration on PE-1 after completing the "Local AS" portion of the AS migration is as follows:

```
        router bgp 200
         neighbor <CE-1_IP> remote-as 100
         neighbor <CE-1_IP> local-as 300 no-prepend
```
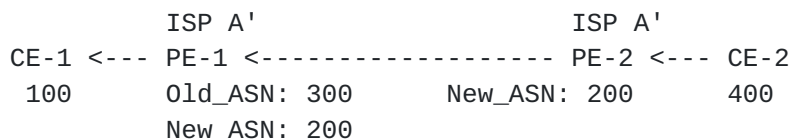
As a result of the "Local AS No Prepend" configuration, on PE-1, CE-2 will see an AS_PATH of: 200 100. CE-2 will not receive a BGP UPDATE containing AS 300 in the AS_PATH. (If only the "local-as 300" feature was configured without the keyword "no-prepend" on PE-1, then CE-2 would see an AS_PATH of: 100 300 200, which is not desirable).

4. **Replace AS: Modify Outbound BGP AS_PATH Attribute**

   The previous feature, "Local AS No Prepend", modifies not only the
   AS_PATH Attribute received from CE devices, but also the AS_PATH
   Attribute transmitted to CE devices as well. Specifically, with
   "Local AS No Prepend" enabled on ISP B's PE, it causes outbound BGP
   UPDATES toward its directly attached eBGP speakers, customer C in AS
   100, to have the AS_PATH Attribute prepended with the new global
   configuration AS on ISP B's PE. The result will be that customer C,
   in AS 100, will receive the following AS_PATH: 300 200 400.
   Therefore, if ISP B takes no further action, it will cause an
   increase in AS_PATH length within customer's networks directly
   attached to ISP B, which is unacceptable.

   A second feature, called "Replace AS", was designed to resolve this
   problem. This feature allows the ISP to not prepend the global
   configured AS in outbound BGP UPDATE's toward customer's networks
   configured with the "Local AS" feature. Instead, only the historical
   (or, legacy) AS will be prepended in the outbound BGP UPDATE toward
   customer's network, restoring the AS_PATH length to what it what was
   before AS Migration occurred.

   To re-use the above diagram, but in the opposite direction, we have:

```
             ISP A'                        ISP A'
     CE-1 <--- PE-1 <------------------- PE-2 <--- CE-2
      100       Old_ASN: 300      New_ASN: 200        400
                New_ASN: 200
```

   Note: Direction of BGP UPDATE as per the arrows.

                 Figure 2: Replace AS BGP UPDATE Diagram

   The final configuration on PE-1 after completing the "Replace AS"
   portion of the AS migration is as follows:

```
             router bgp 200
              neighbor <CE-1_IP> remote-as 100
              neighbor <CE-1_IP> local-as 300 no-prepend replace-as
```

   By default, without "Replace AS" enabled, CE-1 would see an AS_PATH
   of: 300 200 400, which is artificially lengthened by the ASN
   Migration. After ISP A' changes PE-1 to include the "Replace AS"
   feature, CE-1 would receive an AS_PATH of: 200 400, which is the same
   AS_PATH length pre-AS migration.

5. **Additional Operational Considerations**

   This document describes just two variations of implementation-
   specific features to support ISP's and other organizations that need
   to perform ASN migrations. Other variations of these features may
   exist, for example, in legacy router software that has not been
   upgraded or reached End of Life, but continues to operate in the
   network. Such variations are beyond the scope of this document.

   Companies routinely go through periods of mergers, acquisitions and
   divestitures, which in the case of the former cause them to
   accumulate several legacy ASNs over time. Since ISPs often do not
   have control over the configuration of customer's devices, (i.e.: the
   ISPs are often not providing a managed CE router service,
   particularly to medium and large customers that require eBGP), and
   since the ISP is using methods to perform ASN migration that do not
   require coordination with customers, there is not a finite period of
   time that the legacy ASNs will be completely expunged from the ISP's
   network. In fact, it is common that legacy ASNs along with the
   features discussed in this document can and do persist for several
   years if not longer. Thus, it is prudent to plan that legacy ASNs
   and associated features will persist in a operational network
   indefinitely.

6. **Conclusion**

   Although the features discussed in this document are not formally
   recognized as part of the BGP4 specification, they have been in
   existence in commercial implementations for well over a decade.
   These features are widely known by the operational community and will
   continue to be a critical necessity in the support of network
   integration activities going forward. Therefore, these features are
   extremely unlikely to be deprecated by vendors. As a result, these
   features must be acknowledged by protocol designers, particularly
   when there are proposals to modify BGP's behavior with respect to
   handling or manipulation of the AS_PATH Attribute. More
   specifically, assumptions should not be made with respect to the
   preservation or consistency of the AS_PATH Attribute as it is
   transmitted along a sequence of ASNs. In addition, proposals to
   manipulate the AS_PATH that would gratuitously increase AS_PATH
   length or remove the capability to use these features described in
   this document will not be accepted by the operational community.

7. Acknowledgements

   Thanks to Kotikalapudi Sriram for his comments.

8. IANA Considerations

   This memo includes no request to IANA.

9. Security Considerations

   This draft discusses a process by which one ASN is migrated into and
   subsumed by another. This involves manipulating the AS_PATH
   Attribute with the intent of not increasing the AS_PATH length, which
   would typically cause the BGP route to no longer be selected by BGP's
   Path Selection Algorithm in other's networks. This could result in a
   loss of revenue if the ISP is billing based on measured utilization
   of traffic sent to/from entities attached to its network. This could
   also result in sudden, and unexpected shifts in traffic patterns in
   the network, potentially resulting in congestion, in the most extreme
   cases. While this I-D does not introduce any new security
   considerations, as it is simply documenting current functionality,
   the reader should be aware that manipulation if the AS_PATH attribute
   has several known attack vectors that can result in the same sort of
   undesired traffic shifts.

   Given that these features can only be enabled through configuration
   of router's within a single network, standard security measures
   should be taken to restrict access to the management interface(s) of
   routers that implement these features.

10. References

10.1. Normative References

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

10.2. Informative References

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