Monitoring BGP and Route Leaks using OpenBMP and Apache Kafka

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NANOG-65
Traditional Method: **VTY** (cli/netconf/xml)

- Data is polled instead of pushed *(not real-time)*
- Large queries can impact router CPU
- VTY access can be slow and cumbersome
- Requires access credentials per router
- Maintainability is complex due to schema/output syntax changes in different software versions

- Maintaining persistent connections to routers may not be feasible

Paths: (3 available, best #3)
Advertised to peers (in unique update groups):
- 173.39.225.61 192.168.1.1
Path #1: Received by speaker 0
Not advertised to any peer
6939 1299 3356 13445 1343
- 64.71.176.49 from 64.71.176.49 (216.218.252.163)
Origin IGP, localpref 95, valid, external, group-best
Received Path ID 0, Local Path ID 0, version 0
Origin-AS validity: not-found
Traditional Method: Packet Capture

- Requires specific deployment architecture
- Doesn’t work well when peering is multi-hop/iBGP considering multiple interfaces could be used for forwarding packets
- Collector has no or limited visibility into router changes that would effect the feed of captured packets
- Can be a security concern
Traditional Method: BGP Peering

- Can only see what the router selects (post policy with local-RIB selection) — **no pre-policy**
- ADD-PATH imposes more resources on the router and is still limited to post-policy and local-RIB selection (not pre-policy)
- Collector has no visibility of peers (assumptions have to be made)
- Pre-policy would require peering to all peering routers (**does not scale**)
- Standard peering can be a security concern and can jeopardize the router
BMP Overview

- BGP Monitoring Protocol (BMP) encapsulates BGP messages from one or more BGP peers into a single TCP stream to one or more collectors
- Efficient, [near] real-time, low memory/CPU on router, little to no service impact with peering
- Simplified configuration (one-time setup) with granular controls per peer
- All address families supported
- Controlled RIB dumps

OpenBMP Overview

• OpenBMP is an open-source collector that universally makes available both **parsed** and **RAW** BMP data to any number of applications.

• BMP data is forwarded to Apache Kafka in both parsed and BMP raw formats. Any number of consumers can consume this data without requiring multiple BMP feeds from the router.

• The MySQL consumer stores parsed data for simplified consumption to enable granular analytics on BGP data without restrictions.

• The file consumer logs parsed messages and binary RAW BMP messages in files on disk.

• Multiple consumers are available.

• [www.openbmp.org](http://www.openbmp.org) and [github.com/openbmp](https://github.com/openbmp)
 Consumers track their offset and resume where left off when restarted
- When consumer first starts within group, starting point will either be **smallest** or **largest**
- Kafka retention policy defines how far back the consumer can go. Suggested **log.retention.hours** is **36** hours or less
- Slower consumers do not jeopardize other consumers
- Load balancing consumers
- Track offsets and performance using [https://cwiki.apache.org/confluence/display/KAFKA/System+Tools](https://cwiki.apache.org/confluence/display/KAFKA/System+Tools)
Architecture

- Common distributed collection of BGP data
- Multiple consumers leveraging existing BGP data feeds, including binary BMP data feeds
- Integration into live data feed is as simple as consuming data from Kafka
- Application integration can be at the Kafka layer or at the app integration layer
Message Feeds

http://openbmp.org/#!docs/MESSAGE_BUS_API.md

```
bin/kafka-console-consumer.sh  --zookeeper bmp-dev.openbmp.org:2181 \
   --topic openbmp.parsed.unicast_prefix

V: 1
C_HASH_ID: 8d31683940705f39520ccc05bd2d128c
L: 729
R: 2

add 3808297 d82097c34e2e6b2c39c45a97131d62d40080e0d7a01dca408c047568804cbed5
     173.39.209.78  a5f605c1a55b7138c2fe57cc14b0a1311f5c87f0b265b5609a2a5df0621faa7b
     x.x.x.x 3356  2015-08-31 20:44:36.427581  105.96.0.0   22   1
     igp  3356  12956  36947     3  36947  x.x.x.b 0  3356:3 3356:22
     0   1

add 3808298 498a6202fd627d673ec9b0c55aca6d080080e0d7a01dca408c047568804cbed5
     173.39.209.78  a5f605c1a55b7138c2fe57cc14b0a1311f5c87f0b265b5609a2a5df0621faa7b
     x.x.x.x 3356  2015-08-31 20:44:36.427581  81.52.162.0  24   1
     igp  3356  12956  36947     3  36947  x.x.x.b 0  3356:3 3356:22
     0   1
```
As Path Analysis

AS PATH: 3356 1299 13335 13335 13335 { 10310 33612 }

- Order is maintained to allow rebuilding the distinct AS Path
- Extract each ASN and their respective LEFT and RIGHT ASNs by iterating through the AS PATH
- Upstream ASN is LEFT ASN, Downstream is RIGHT ASN
- Transit is ASN with non-ZERO RIGHT
- Peering is ASN with zero LEFT
- Originating ASN is ASN with zero RIGHT

Result: \{ \text{ASN, LEFT, RIGHT} \}

\{3356, 0, 1299\}
\{1299, 3356, 13335\}
\{13335, 1299, 10310\}
\{10310, 13335, 33612\}
\{33612, 10310, 0\}
A route leak is when routes are advertised to a BGP peer when they shouldn’t have been (wrongfully advertised)

- Is intentional or unintentional
- Can impact few prefixes or many (thousands) prefixes
- Not just Unicast/Internet prefixes, can also be VPNv4/v6 prefixes
- Not limited to originating ASN of prefix
- Agreed policies not being enforced can be considered leaking
Several techniques are used to prevent route-leaking, but prefixes can still slip through the cracks

- Not limited to just advertisement or withdrawal of a prefix, it also includes wrongly applied prepending/local-pref/etc.
- In some cases, policies may conflict, such as preferring wholesale over transit, which may use more relaxed filters
- Maximum prefixes doesn’t help when it’s just a few that get advertised inadvertently
- Mistakes can be made with filters, both programmatically and human applied
- RIR, IRR, RPKI, etc. primarily focus on assigned address blocks by originating ASN for registered addresses, leaving VPNv4/v6 out of scope
Route Leak: More Specific Observed

- Check if prefix aggregate ASN matches itself
- Check if aggregate ASN is upstream of prefix ASN
- Alert otherwise
- ~8000 prefixes match with no normalization/baseline

```
SELECT r.prefix as RibPrefix, r.prefix_len as RibLen, r.origin_as as RibOriginAs,
       agg.prefix as AggPrefix, agg.prefix_len as AggPrefixLen, agg.origin_as as AggOriginAs
FROM rib r
JOIN rib agg ON (r.prefix.bin = agg.prefix.bcast_bin and
                r.prefix.bin >= agg.prefix.bin and r.prefix_len > agg.prefix_len)
LEFT JOIN as_path_analysis a ON (a.asn = r.origin_as and a.asn_left = agg.origin_as)
WHERE r.isWithdrawn = False AND agg.isWithdrawn = False
    AND r.origin_as != agg.origin_as
    AND a.asn is null
GROUP BY agg.prefix_bin, agg.prefix_len
```
Route Leak: Originating ASN Inconsistent

- Check if prefix is actively advertised by other peers with a different originating ASN
- If history includes multiple ASNs but only one active, prefix has likely relocated instead of possible hijack
- ~1000 prefixes match with no normalization/baseline

```
SELECT r.prefix as RibPrefix, r.prefix_len as RibLen, r.origin_as as RibOriginAs, count(distinct r.origin_as) as count, sum(if(isWithdrawn = False, 1, 0)) as sum_count 
FROM rib r 
WHERE origin_as != 23456 
GROUP BY r.prefix_bin,r.prefix_len 
HAVING count > 1;
```
Route Leak: Unknown Upstream Observed

- Check if adjacent ASN has previously been seen for the originating ASN

```sql
SELECT distinct asn_left from as_path_analysis
WHERE asn = 109 AND asn_left != 0
ORDER BY asn_left;
```
Route Leak: Selection Attribute Changed

Attributes change often, monitoring for such events should take this into account by alerting when multiple prefixes are affected or by snapshotting before/after change

**Snapshotting**
- Snapshot topology **before** and **after** a change. Report showing prefixes changed by local preference, as path length (including “this” ASN prepends added or removed), well-known community added/removed, MED, …

**Scheduled Report**
- Uses snapshotting technique but run on a schedule instead of before/after a change

**Watch List**
- Alert on specific communities or community pattern/convention being added/removed
- Alert on specific prefixes
- Alert on specific originating or transit ASNs
- Watch any attribute and alert if change from previous, this includes the lack of or presence of an attribute
Route Leak: Transit and Origination

Traffic shifting by peer, transit/originating ASN, or by community results in significant prefixes changing in attributes (e.g. next hop, communities, …). A significant change in prefixes seen by transit and/or originating ASNs could be a route leak.
Analytics

There are many types of analytics but at a high level, most would fall under one of the below

- **Real-Time**
  - Alert if a specific condition presents itself, such as prefixes change to traverse a sub-optimal AS

- **On-demand**
  - Transit AS increases significantly in number of prefixes that would be preferred, trigger an analysis to correlate impacted prefixes

- **Discovery & Investigation**
  - Report on the number of distinct prefixes that traverse a specific transit AS over time

- **Topologies**
  - Management application queries for topology data to correlate impact events by source and destination IP addresses

OpenBMP and Apache Kafka can be utilized to collect and analyze historical and real-time BGP data with custom and third-party applications
Install OpenBMP today using docker hub openbmp/aio

For more details see:

http://openbmp.org/#!docs/INSTALL.md
Questions?
Thank You

www.openbmp.org

github.com/OpenBMP