



INEX's Shiny New Route Servers

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Internet Neutral Exchange Association

Company Limited by Guarantee



RPKI

IRRDB vs. RPKI ROAs

route6: 2001:db8::/32
descr: Example IPv6 route object
origin: AS65500
created: 2006-07-12T16:11:58Z
last-modified: 2011-02-22T15:58:03Z
source: SOME-IRRDB

route: 192.0.2.0/24
descr: Example IPv4 route object
origin: AS65500
created: 2004-12-06T11:43:57Z
last-modified: 2016-11-16T22:19:51Z
source: SOME-IRRDB

RPKI

ROAs - Route Origin Authorisations

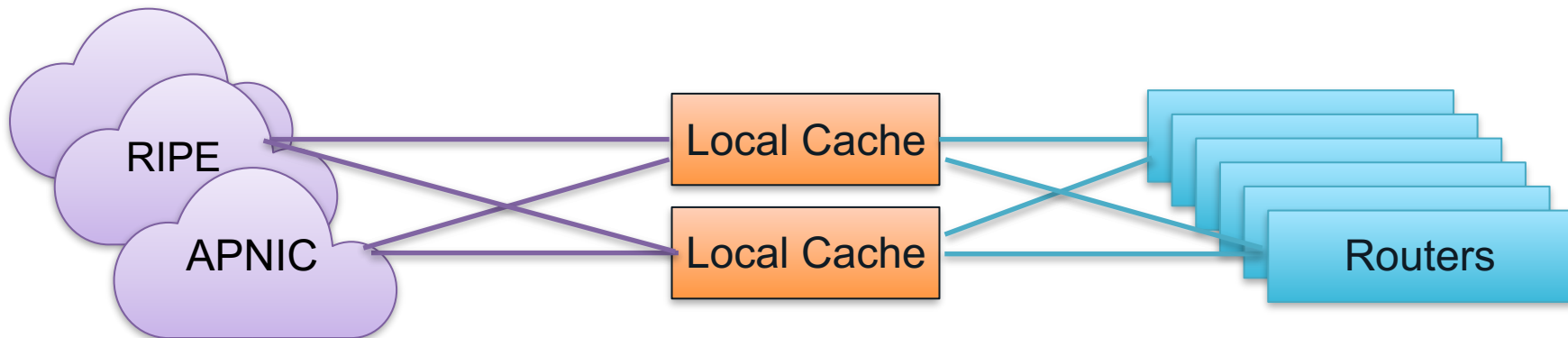
- A cryptographically secure replacement for route[6] objects
- Adds maximum prefix length
- Yields route origin triplets that have been validated

```
( Origin AS, Prefix, Max Length )  
( AS65500, 2001:db8::/32, /48 )  
( AS65501, 192.0.2.0/24, /24 )
```

RPKI

Validating BGP Routing with RPKI-RTR

- A cache server (*validator*) does the cryptographic heavy lifting
- Routers receive and maintain the set of ROAs via RPKI-RTR from the cache
- RPKI gives three validation results: VALID, INVALID, UNKNOWN



The logo consists of the letters "RPKI" in white, bold, sans-serif font, centered within a solid green square.

Creating ROAs

- Use the RIPE LIR Portal - it's really easy
 - Multi-user support
 - Two-factor authentication
 - BGP route collector suggestions
 - Auto-renew ROAs



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Request Resources

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IPv4 Transfer Listing
Service

RPKI Dashboard

RIPE Database >





RIPE NCC



RIPE NETWORK COORDINATION CENTRE



BGP Announcements **Route Origin Authorisations (ROAs)** **History**

  Create ROAs for selected BGP Announcements

☒ Valid ☒ Invalid ☒ Unknown

<input type="checkbox"/> Origin AS	Prefix	Current Status	
<input type="checkbox"/> AS65500	192.0.2.0/24	UNKNOWN	 

Show of 8 items

RPKI

ROAs on the INEX Route Collector

```
bird> show route
  filter {
    if bgp_large_community ~ [( 2128, 1000, 1 )] then accept;
  }
table master4 count
```

17710 of 244895 routes for **144834** networks in table master4

=> 12.2% of routes at INEX have a ROA

RPKI

ROAs on the INEX Route Collector

```
bird> show route
  filter {
    if bgp_large_community ~ [( 2128, 1101, 13 )] then accept;
  }
table master4 count
```

535 of 244890 routes for **144825** networks in table master4

=> 0.2% of routes at INEX have an invalid ROA

** 466 of these are via HE, 53 via Virgin Media; leaving only 16 for the other 98 route collector sessions*



ROAs on the INEX Route Collector

AS6939	(1)	HE	11,346
AS6830	(2)	Virgin Media	3,799
AS8220	(3)	Colt	414
AS21320	(4)	GEANT	362
AS16509	(5)	AWS	307
AS13237	(6)	euNetworks	211
AS43531	(7)	IX Reach	88

AS15830	(11)	Equinix	53/322
AS5466	(13)	eir	26/77
AS207044	(14)	enet	22/53
AS31122	(15)	Viatel	20/64
AS34245	(15)	Magnet	20/22
AS39122	(16)	Blacknight	20/53
AS1213	(17)	HEAnet	12/23
AS2110	(17)	BT Ireland	12/95

RPKI

ROAs on the INEX Route Collector [27/03/2019, 56 ASNs]

11651	6939	12	56911	2	62129
3882	6830	12	1213	2	61145
515	8220	10	8075	2	44384
377	21320	9	42	2	43192
307	16509	8	7713	2	41678
248	13237	8	51677	2	41073
91	43531	7	42473	2	39093
90	702	7	25441	2	31641
89	5400	5	44451	2	200562
74	15169	5	35226	2	199346
53	15830	5	15533	2	197853
31	22822	5	13335	2	15612
27	31122	4	39449	1	39319
26	5466	4	200005	1	3856
22	207044	4	199256	1	30900
21	39122	3	61194	1	203754
21	34245	3	60277	1	201607
20	14537	3	50326	1	12388
19	2110	3	32934		



NEW ROUTE SERVERS

INEX's Shiny New Route Servers



NEW ROUTE SERVERS

Route Server Refresh at INEX & IXP Manager

- RPKI just one element
- Upgrade configuration from Bird v1.6 to Bird v2.0
- Complete rewrite of filtering workflow
 - Large communities used extensively within the route server
- Upgrade Bird's Eye¹ for Bird v2 BGP
- Overhaul IXP Manager looking glass

1. A secure micro service for querying Bird - <https://github.com/inex/birdseye>

NEW ROUTE SERVERS


Bird v1 to v2 Changes

- RPKI-RTR supported
- Collapsed separate daemons for IPv4 and IPv6 into a single daemon
 - master route table becomes master4 / master6
 - new protocol blocks: `ipv4 { ... } / ipv6 { ... }`
- Other very minor configuration changes

NEW ROUTE SERVERS

Bird v1 to v2 Changes

```
protocol bgp pb_as112_vli249_ipv4 {  
    description "AS112";  
    local as routerasn;  
    source address 192.0.2.8;  
    neighbor 192.0.2.6 as 112;  
    import all;  
    export none;  
    table master;  
}
```



```
protocol bgp pb_as112_vli249_ipv4 {  
    description "AS112";  
    local as routerasn;  
    source address 192.0.2.8;  
  
    neighbor 192.0.2.6 as 112;  
    ipv4 {  
        import all;  
        export none;  
        table master4;  
    };  
}
```

NEW ROUTE SERVERS

Standard IX Route Server Community Filters

Description	Community	Large Community
Prevent announcement of a prefix to a certain peer	0:peer-as	43760:0:peer-as
Announce a prefix to a certain peer	43760:peer-as	43760:1:peer-as
Prevent announcement of a prefix to all peers	0:43760	43760:0:0
Announce a prefix to all peers	43760:43760	43760:1:0

Path prepends now available: <https://www.inex.ie/technical/route-servers/>

NEW ROUTE SERVERS

Route Server BGP Community Usage

Description	Large Community
RPKI Valid	43760:1000:1
RPKI Unknown	43760:1000:2
IRRDB Valid	43760:1001:1
...	...

Description	Large Community
Bogon Prefix	43760:1101:3
IRRDB Invalid	43760:1101:9
RPKI Invalid	43760:1101:13
...	...

NEW ROUTE SERVERS

43760:1101:* are filtered

Route Server BGP Community Usage

Description	Large Community
RPKI Valid	43760:1000:1
RPKI Unknown	43760:1000:2
IRRDB Valid	43760:1001:1
...	...

Description	Large Community
Bogon Prefix	43760:1101:3
IRRDB Invalid	43760:1101:9
RPKI Invalid	43760:1101:13
...	...

NEW ROUTE SERVERS

IXP Manager v5 Route Server Filtering

1. Small prefixes (default is $> /24$ / $/48$ for ipv4 / ipv6)
2. Martians / bogons
3. Ensure at least 1 ASN and ≤ 64 ASNs in path
4. Ensure peer AS is the same as first AS in the prefix's AS path
5. Prevent next-hop hijacking
6. Filter known transit networks
7. Ensure origin AS is in set of ASNs from member AS-SET
8. RPKI:
 - Valid -> accept
 - Invalid -> drop
9. RPKI Unknown -> revert to standard IRRDB prefix filtering

NEW ROUTE SERVERS

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NEW ROUTE SERVERS

Filter Known Transit Networks

These do not peer at IX's and they aren't typically customers of IX participants

```

14  define TRANSIT_ASNS = [ 174,           # Cogent
15                          209,           # Qwest (HE carries this on IXPs IPv6 (Jul 12 2018))
16                          701,           # UUNET
17                          702,           # UUNET
18                          1239,          # Sprint
19                          1299,          # Telia
20                          2914,          # NTT Communications
21                          3257,          # GTT Backbone
22                          3320,          # Deutsche Telekom AG (DTAG)
23                          3356,          # Level3
24                          3549,          # Level3
25                          3561,          # Savvis / CenturyLink
26                          4134,          # Chinanet
27                          5511,          # Orange opentransit
28                          6453,          # Tata Communications
29                          6461,          # Zayo Bandwidth
30                          6762,          # Seabone / Telecom Italia
31                          7018 ];         # AT&T

```

NEW ROUTE SERVERS

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NEW ROUTE SERVERS

Ensure Origin AS is Member's AS-SET

```
as-set:          AS-HEANET
descr:           Autonomous Systems routed by HEAnet
members:         AS1213, AS2128, AS112, AS42310, AS2850, AS-IEDR
remarks:         Group ASs routed by HEAnet together
mnt-by:          HEANET-NOC
source:          RIPE
```

NEW ROUTE SERVERS

Ensure Origin AS is Member's AS-SET

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descr:           Autonomous Systems routed by HEAnet
members:         AS1213, AS2128, AS112, AS42310, AS2850, AS-IEDR
remarks:         Group ASs routed by HEAnet together
mnt-by:          HEANET-NOC
source:          RIPE
```

No ability to create AS sets in RPKI

draft-ietf-grow-rpki-as-cones will resolve this

This is a regression over static IRRDB filtering

NEW ROUTE SERVERS

IXP Manager v5 Route Server Filtering

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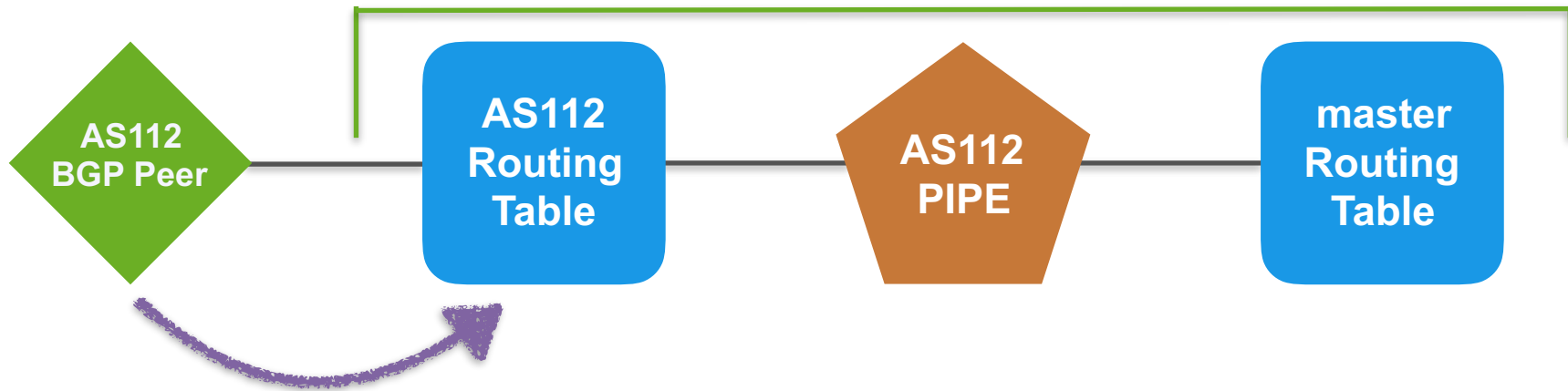
NEW ROUTE SERVERS

IXP Manager v5 Bird Topology - Import From Member



NEW ROUTE SERVERS

IXP Manager v5 Bird Topology - Import From Member

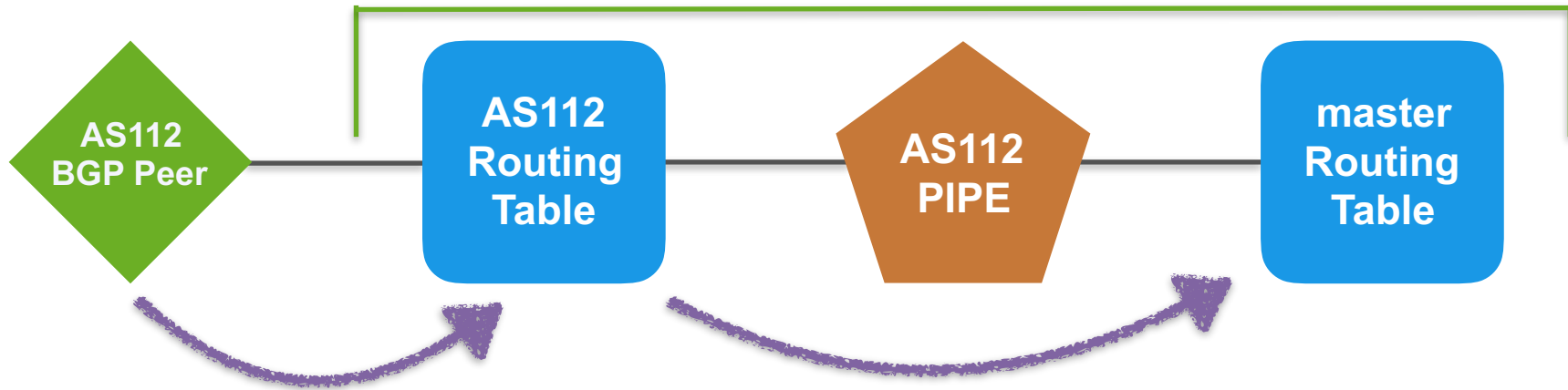


BGP import filter checks
prefixes and tags for
later filtering

*(we want them in the AS112
RT for the looking glass / analysis)*

NEW ROUTE SERVERS

IXP Manager v5 Bird Topology - Import From Member



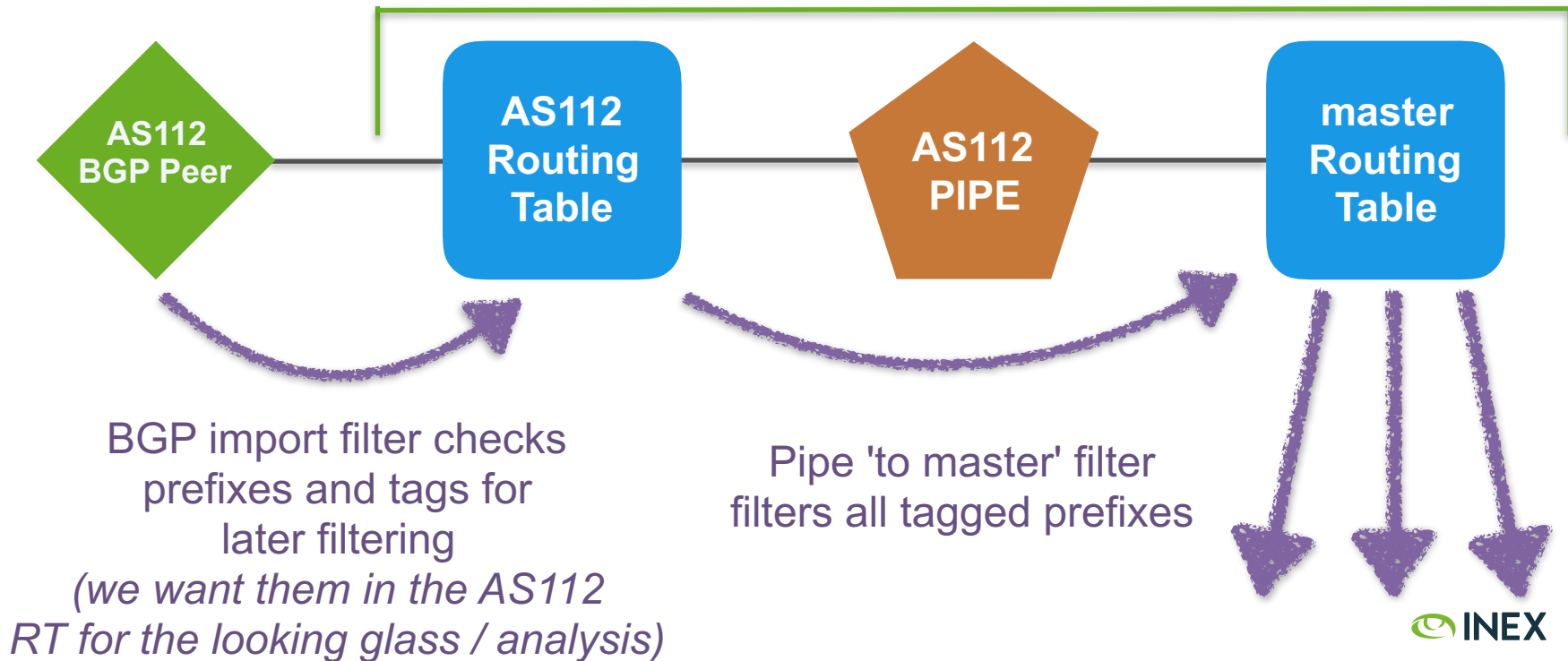
BGP import filter checks
prefixes and tags for
later filtering

*(we want them in the AS112
RT for the looking glass / analysis)*

Pipe 'to master' filter
filters all tagged prefixes

NEW ROUTE SERVERS

IXP Manager v5 Bird Topology - Import From Member



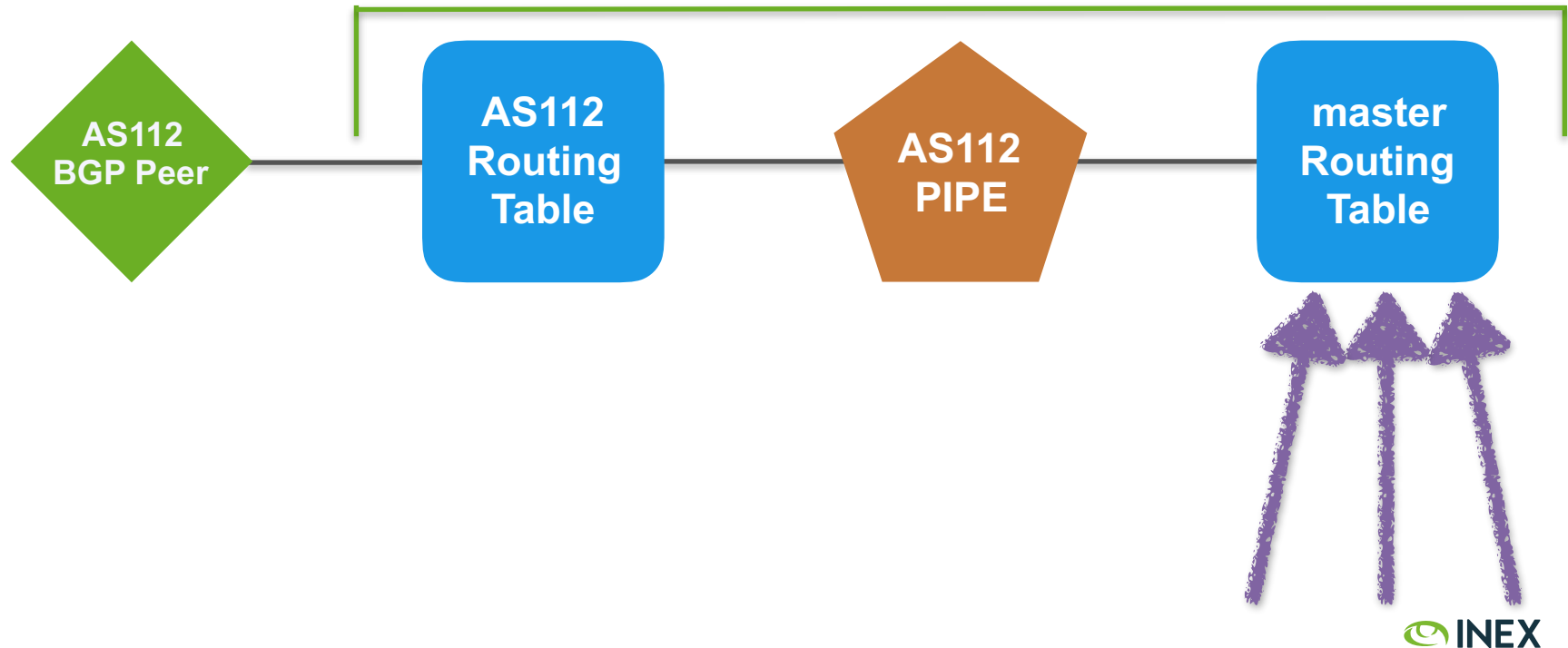
NEW ROUTE SERVERS

IXP Manager v5 Bird Topology - Export To Member



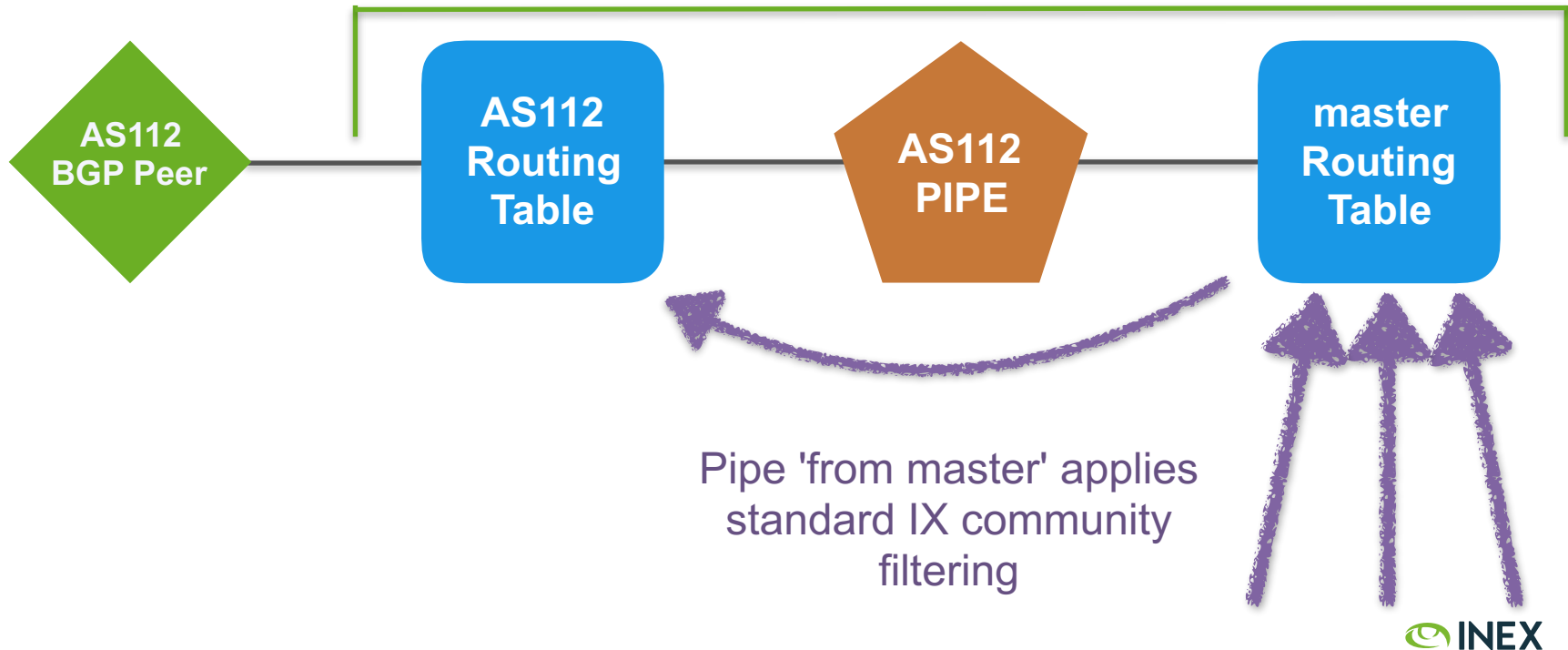
NEW ROUTE SERVERS

IXP Manager v5 Bird Topology - Export To Member



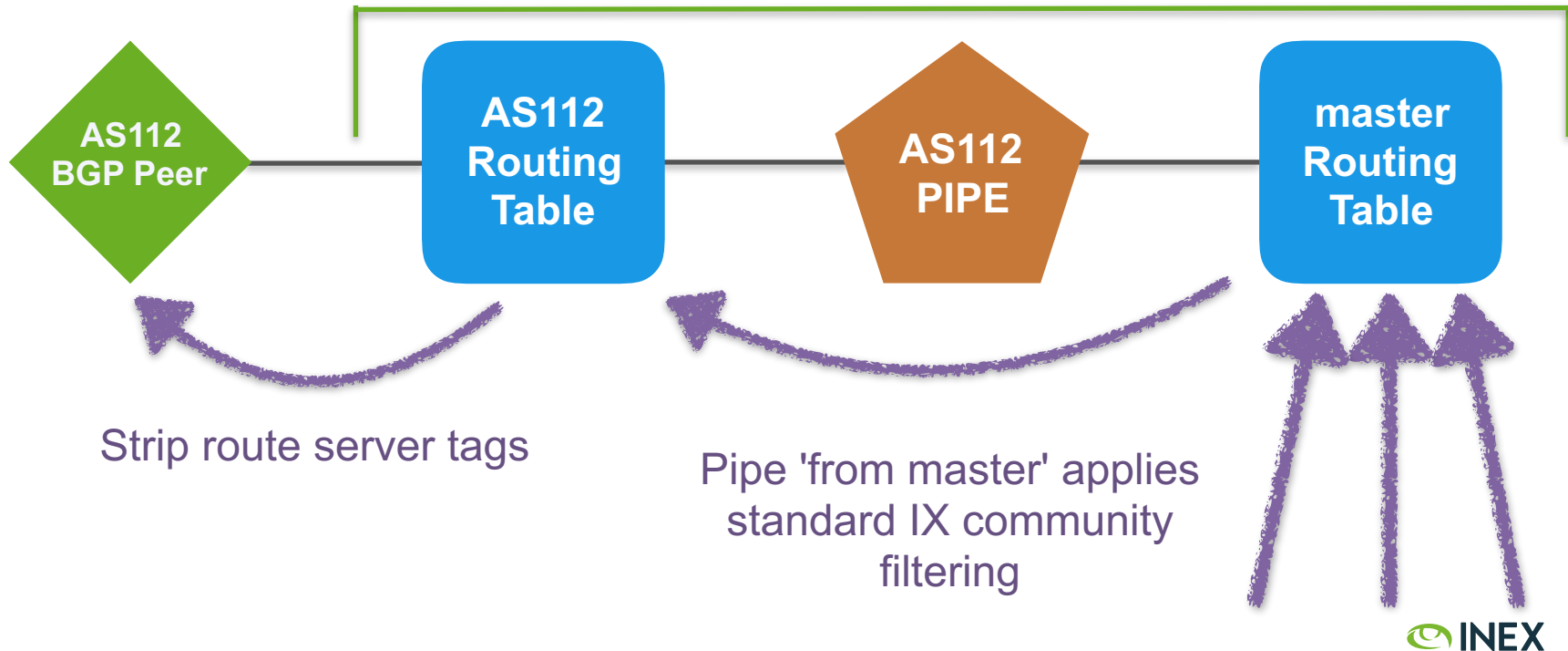
NEW ROUTE SERVERS

IXP Manager v5 Bird Topology - Export To Member



NEW ROUTE SERVERS

IXP Manager v5 Bird Topology - Export To Member





RPKI @ INEX

RPKI Implementation Notes

Validator Software - RIPE NCC RPKI Validator 3

- RIPE NCC RPKI Validator 3 released in 2018
 - <https://github.com/RIPE-NCC/rpki-validator-3>
- Dramatically reduces installation complexity
- Modest VM requirements, runs on standard OS distributions
- Requirement to download ARIN TAL separately

```
$ wget https://ftp.ripe.net/tools/rpki/validator3/rc/generic/rpki-validator-latest-dist.tar.gz
$ tar xzf rpki-validator-latest-dist.tar.gz
$ ./rpki-validator-3.0-x/rpki-validator-3.sh
$ open http://localhost:8080
```

```
$ wget https://ftp.ripe.net/tools/rpki/validator3/rc/generic/rpki-rtr-server-latest-dist.tar.gz
$ tar xzf rpki-rtr-server-latest-dist.tar.gz
$ ./rpki-rtr-server/rpki-rtr-server-3.sh
```

Validator Software - Routinator 3000

- Routinator 3000 by NLnet Labs
 - <https://github.com/NLnetLabs/routinator>
- First impressions: low overhead, installation simplicity, stable, "just works"
- Requirement to download ARIN TAL separately

```
$ curl https://sh.rustup.rs -sSf | sh
$ source ~/.cargo/env
$ cargo install routinator
$ routinator rtrd -al 127.0.0.1:3323
```


Validator Software - RPKI-RTR and Bird

```
roa4 table t_roa;  
  
protocol rpki rpki1 {  
  
    roa4 { table t_roa; };  
  
    remote "192.0.2.67" port 3323;  
  
    retry keep 90;  
    refresh keep 900;  
    expire keep 172800;  
}
```

RPKI @ INEX

Validator Software - RPKI-RTR and Bird

```
# RPKI check
rpki_result = roa_check( t_roa, net, bgp_path.last_nonaggregated );

if( rpki_result = ROA_INVALID ) then {
    ...
}

# or ROA_VALID / ROA_UNKNOWN
```

Implementation Process at INEX

- INEX has two route servers and a route collector per LAN
- Upgrade route collector to Bird v2 + RPKI first
 - identify members who peer on the route server with RPKI invalid prefixes
 - found 4 members of ~80 with issues
 - 1 x more specific advertised than ROA allowed for
 - 1 x origin AS not matching ROA
 - 1 x member still advertising transferred space, new owners had ROAs
 - 1 x member created ROA for upstream peer-as rather than origin-as
 - members alerted to this on a "FYI basis" (i.e. non-blocking for INEX)
- Route server #1 completed Feb 7th
- Route server #2 completed Feb 14th

Implementation Process at INEX

- Outside of the four members with issues, no other member issues
- No issues to date with Bird v2
- Some issues with RIPE's validator (crashing, disk space)
- No issues with Routinator 3000
- There's a lot in this (Bird v2, route collector vs server, large community tagging and filtering, RPKI vs IRRDB, etc.)

Looking Glass INEX Cork - Route Collector - IPv4

INEX Cork - Route Collector - IPv4 ▾



This is the public looking glass. Uncached results and additional routers available when logged in.

Bird v2 2.0.3 | API: 1.2.0 | Router ID: 185.1.69.126 | Uptime: 11 days. | Last Reconfigure: 2019-02-16 15:12:02 | JSON: [\[status\]](#) [\[bgp\]](#)

Search:

Neighbor	Description	ASN	Table	PfxLimit	State/PfxRcd	PfxExp	Actions
185.1.69.6	AS112 - AS112 Reverse DNS	112	master4		2	0	Details
185.1.69.24	AS714 - Apple Distribution International	714	master4		596	0	Details
185.1.69.26	AS714 - Apple Distribution International	714	master4		597	0	Details
185.1.69.11	AS1213 - HEAnet	1213	master4		23	0	Details
185.1.69.12	AS5466 - Eir	5466	master4		77	0	Details
185.1.69.17	AS15405 - East Cork Broadband	15405	master4		5	0	Details
185.1.69.14	AS16171 - Strencom	16171	master4		4	0	Details
185.1.69.16	AS20940 - Akamai Technologies	20940	master4		1	0	Details
185.1.69.23	AS25152 - RIPE NCC k-root server	25152	master4		1	0	Details
185.1.69.10	AS31122 - Viatel	31122	master4		90	0	Details
185.1.69.19	AS41736 - Nova Telecom	41736	master4		3	0	Details
185.1.69.21	AS42090 - Rapid Broadband	42090	master4		6	0	Details

Looking Glass

INEX Cork - Route Collector - IPv4

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185.1.69.6	AS112 - AS112 Reverse DNS	112	master4		2	0	Details
185.1.69.24	AS714 - Apple Distribution International	714	master4		596	0	Details
185.1.69.26	AS714 - Apple Distribution International	714	master4		597	0	Details
185.1.69.11	AS1213 - HEAnet	1213	master4		23	0	Details
185.1.69.12	AS5466 - Eir	5466	master4		77	0	Details
185.1.69.17	AS15405 - East Cork Broadband	15405	master4		5	0	Details
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185.1.69.16	AS20940 - Akamai Technologies	20940	master4		1	0	Details
185.1.69.23	AS25152 - RIPE NCC k-root server	25152	master4		1	0	Details
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185.1.69.19	AS41736 - Nova Telecom	41736	master4		3	0	Details
185.1.69.21	AS42090 - Rapid Broadband	42090	master4		6	0	Details

Network	Next Hop	Metric	Communities?	AS Path	
104.132.227.0/24	185.1.69.12	P 100	1 LC: 2	5466 41264	Details
109.125.0.0/18	185.1.69.12	P 100	1 LC: 2	5466 15751	Details
132.189.78.0/24	185.1.69.12	P 100	1 LC: 3 ⚠	5466 8116	Details
132.189.79.0/24	185.1.69.12	P 100	1 LC: 3 ⚠	5466 8116	Details
132.237.132.0/24	185.1.69.12	P 100	1 LC: 2	5466 30614	Details
132.237.167.0/24	185.1.69.12	P 100	1 LC: 2	5466 30614	Details
134.191.192.0/24	185.1.69.12	P 100	1 LC: 2	5466 4983	Details
134.191.216.0/22	185.1.69.12	P 100	1 LC: 2	5466 4983 4983 4983 4983 4983 4983 4983 4983 4983	Details
134.191.220.0/23	185.1.69.12	P 100	1 LC: 2	5466 4983 4983 4983 4983 4983 4983 4983 4983 4983	Details
134.191.240.0/22	185.1.69.12	P 100	1 LC: 3 ⚠	5466 4983	Details
134.191.244.0/24	185.1.69.12	P 100	1 LC: 3 ⚠	5466 4983	Details
134.191.246.0/23	185.1.69.12	P 100	1 LC: 2	5466 4983	Details
135.74.153.0/24	185.1.69.12	P 100	1 LC: 3 ⚠	5466 18676	Details
146.214.64.0/23	185.1.69.12	P 100	1 LC: 3 ⚠	5466 42213	Details

Network	Next Hop		Metric	Communities?	AS Path		
104.132.227.0/24	185.1.69.12	P	100	1 LC: 2	5466 41264		Details
109.125.0.0/18	185.1.69.12	P	100	1 LC: 2	5466 15751		Details
132.189.78.0/24	185.1.69.12	P	100	1 LC: 3 A	5466 8116		Details
132.189.79.0/24	185.1.69.12	P	100	1 LC: 3 A	5466 8116		Details
132.237.132.0/24	185.1.69.12	P	100	1 LC: 2	5466 30614		Details
132.237.167.0/24	185.1.69.12	P	100	1 LC: 2	5466 30614		Details
134.191.192.0/24	185.1.69.12	P	100	1 LC: 2	5466 4983		Details
134.191.216.0/22	185.1.69.12	P	100	1 LC: 2	5466 4983 4983 4983 4983 4983 4983 4983 4983 4983		Details
134.191.220.0/23	185.1.69.12	P	100	1 LC: 2	5466 4983 4983 4983 4983 4983 4983 4983 4983 4983		Details
134.191.240.0/22	185.1.69.12	P	100	1 LC: 3 A	5466 4983		Details
134.191.244.0/24	185.1.69.12	P	100	1 LC: 3 A	5466 4983		Details
134.191.246.0/23	185.1.69.12	P	100	1 LC: 2	5466 4983		Details
135.74.153.0/24	185.1.69.12	P	100	1 LC: 3 A	5466 18676		Details
146.214.64.0/23	185.1.69.12	P	100	1 LC: 3 A	5466 42213		Details

Route Details - 132.189.78.0/24 as received from protocol pb_as5466_vli223_ipv4

Network	132.189.78.0/24
Gateway	185.1.69.12 PRIMARY
From Protocol	pb_as5466_vli223_ipv4
Age	2019-02-12 09:12:03
Metric	100
Type	BGP univ
BGP :: AS Path	5466 8116
BGP :: Local Pref	100
BGP :: Communities	5466:20
BGP :: Large Communities	2128:1000:2 RPKI UNKNOWN 2128:1101:9 IRRDB PREFIX FILTERED 2128:1001:1001 IRRDB FILTERED STRICT

[Close](#)


RPKI @ INEX

New Route Server Filtered Prefixes Tool


RPKI @ INEX

New *Route Server Filtered Prefixes* Tool

Your INEX - IXP Manager Dashboard



Overview Details Ports Cross Connects **Filtered Prefixes »** Peering Manager » Statistics » Peer to Peer Traffic »

Aggregate Traffic Statistics 

Recent Members

Our five most recent members are listed below. Have you arranged peering with them yet?

Route Server Filtered Prefixes

Bad news! We found 9 prefix(es) that are currently being filtered.

These are listed below with the reason for the filtering and the route server where filtering has been applied.

Prefix	Filtered Because	Filtered On Router(s)	
87.232.5.0/24	IRRDB PREFIX FILTERED	rs1-lan1-ipv4	rs2-lan1-ipv4
87.232.128.0/21	RPKI INVALID	rs1-lan1-ipv4	rs2-lan1-ipv4
87.232.64.0/18	NEXT HOP NOT PEER IP	rs1-lan1-ipv4	rs2-lan1-ipv4
87.232.32.0/19	RPKI INVALID	rs1-lan1-ipv4	rs2-lan1-ipv4
91.197.36.0/22	TRANSIT FREE ASN	rs1-lan1-ipv4	rs2-lan1-ipv4

THANK YOU

Any Questions?