INEX

IXP Route Servers with RPKI and IXP Manager

GPF 14, April 2019, Montréal

Barry O'Donovan
@ComePeerWithMe / @barryo79

INEX

- Peering point for the island of Ireland, member owned association, not for profit, founded in 1996
- ~100 members (inc. ~98% of eyeballs)
- >300Gbps of IP data exchanged at peek
- Dual infrastructure, 8 PoPs, own dark fibre
- Opened INEX Cork in 2016
- IXP Manager / Salt / Napalm automation
- Home of IXP Manager

RPKI at IXPs

IXP Manager

- An INEX project
- Full-stack management system for IXPs
- FOSS - GPL v2 license
- Complete route server automation
- In use at ~70 IXPs worldwide

https://www.ixpmanager.org/

github.com/inex/IXP-Manager

IXP MANAGER SPONSORS

https://www.ixpmanager.org/

github.com/inex/IXP-Manager

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
```

1. BGP filtering automation tool: https://github.com/snar/bgpq3

RPKI

ROAs - Route Origin Authorisations

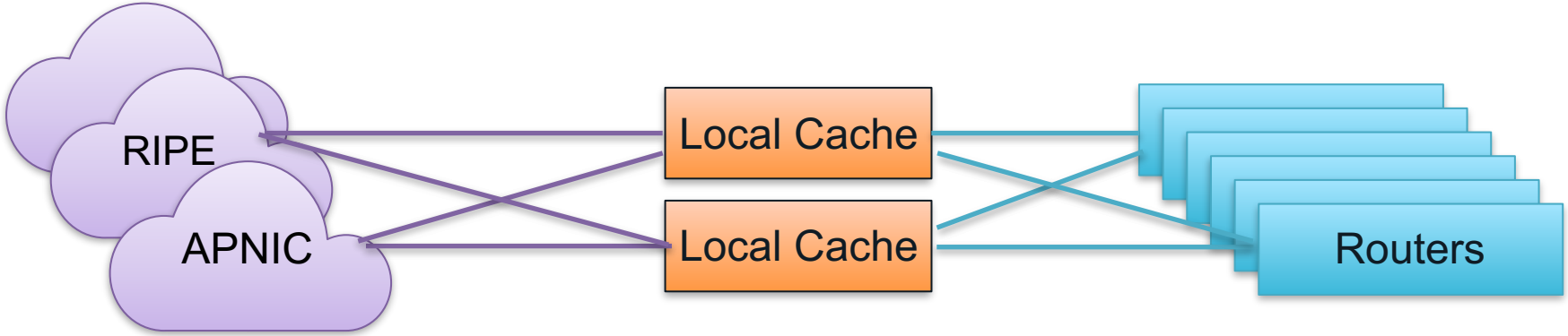
- A cryptographically secure replacement for route[6] objects
- Adds maximum prefix length
- Yields route origin triplets that have been validated

```
( 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



RPKI

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

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

RPKI

ROAs on the INEX Route Servers

- Routes with a valid ROA:
  - **6639** routes of **48916**
  - ~14%
- Some bigger networks skew those results - remove them:
  - **663** routes of **2669**
  - ~25%
  - RIPE's statistics have IE IPv4 prefixes valid at 33%
- Invalids on route collector: **535 of 144825 (0.2%)**
  - 466 of these are via HE, 53 via Virgin Media; leaving only 16 for the other 98 route collector sessions

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 Eye[1] 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;
    };
}
```

Side note

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 a all peers	`43760:43760`	`43760:1:0`

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

Side note

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
…	…

1. https://github.com/euro-ix/rs-workshop-july-2017/wiki/Route-Server-BGP-Community-usage

NEW ROUTE SERVERS

Route Server BGP Community Usage

43760:1101:* are filtered

Side note

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
…	…

1. https://github.com/euro-ix/rs-workshop-july-2017/wiki/Route-Server-BGP-Community-usage

NEW ROUTE SERVERS

IXP Manager v5 Route Server Filtering

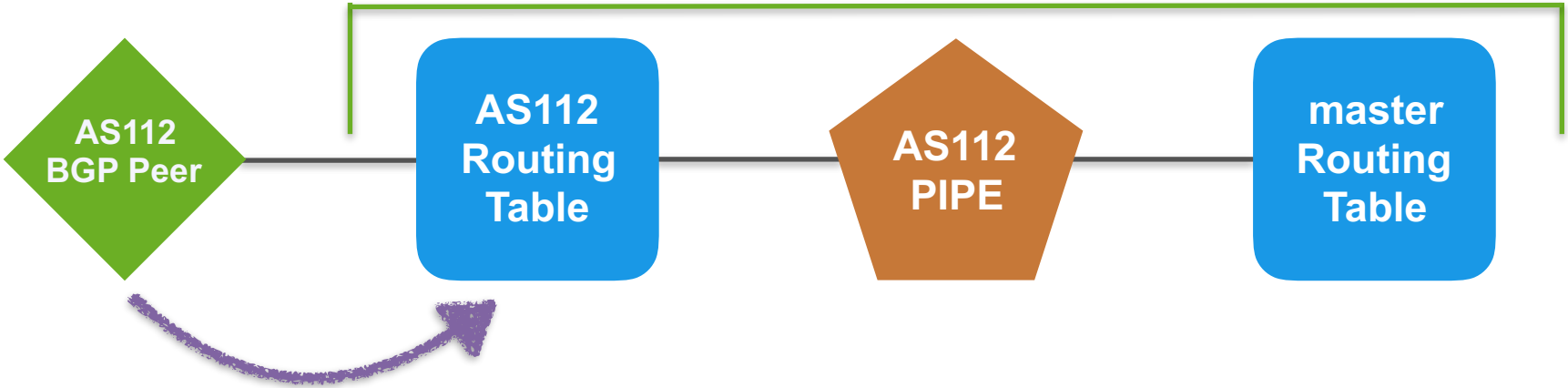
1. Small prefixes (default is > /24 / /48 for ipv4 / ipv6)
2. Martians / bogons
3. Ensure at least 1 ASN and <= 64 ASNs in path
4. Ensure peer AS is the same as first AS in the prefix's AS path
5. Prevent next-hop hijacking
6. Filter known transit networks
7. Ensure origin AS is in set of ASNs from member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

NEW ROUTE SERVERS

IXP Manager v5 Bird Topology - Import From Member

NEW ROUTE SERVERS

IXP Manager v5 Bird Topology - Import From Member

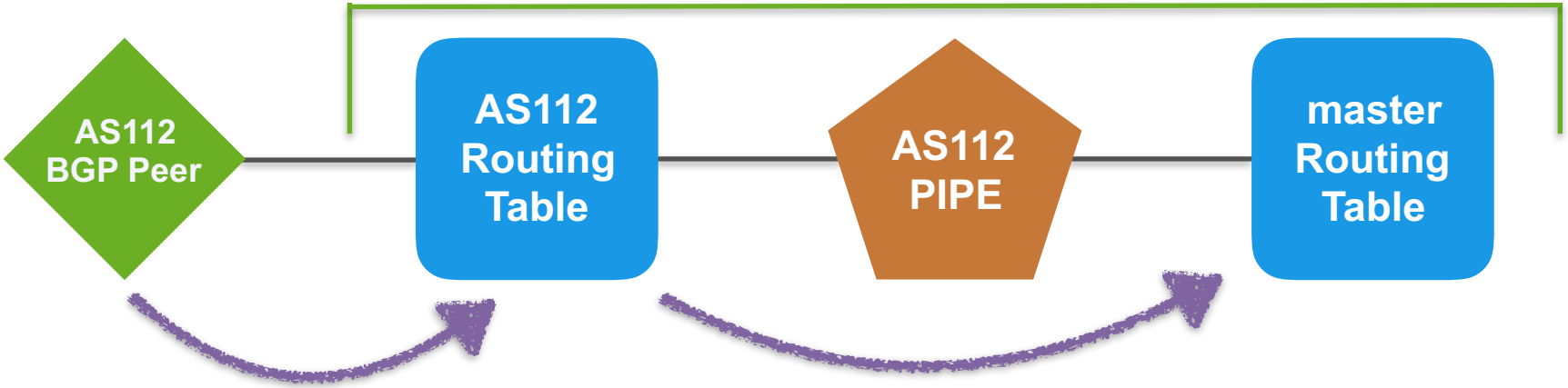


BGP import filter checks prefixes and tags for later filtering

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

NEW ROUTE SERVERS

IXP Manager v5 Bird Topology - Import From Member

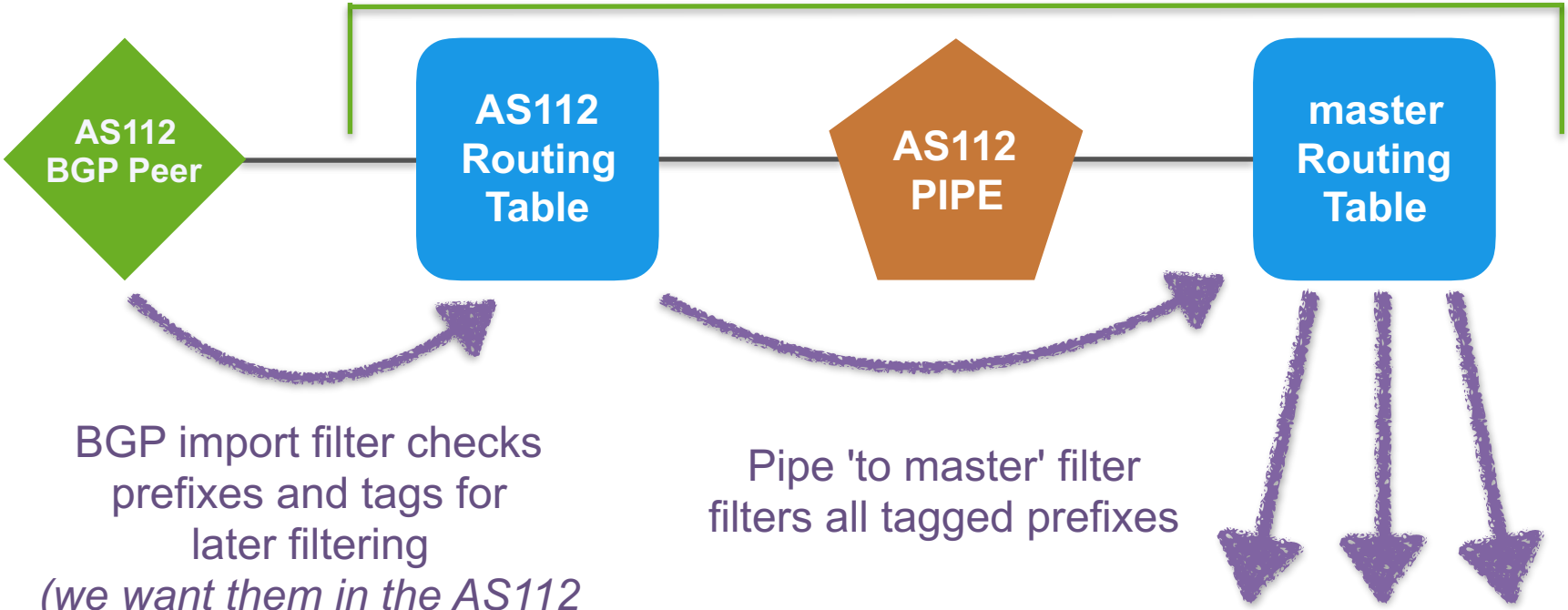


BGP import filter checks prefixes and tags for later filtering
(we want them in the AS112 RT for the looking glass / analysis)

Pipe 'to master' filter filters all tagged prefixes

NEW ROUTE SERVERS

IXP Manager v5 Bird Topology - Import From Member



BGP import filter checks prefixes and tags for later filtering
(we want them in the AS112 RT for the looking glass / analysis)

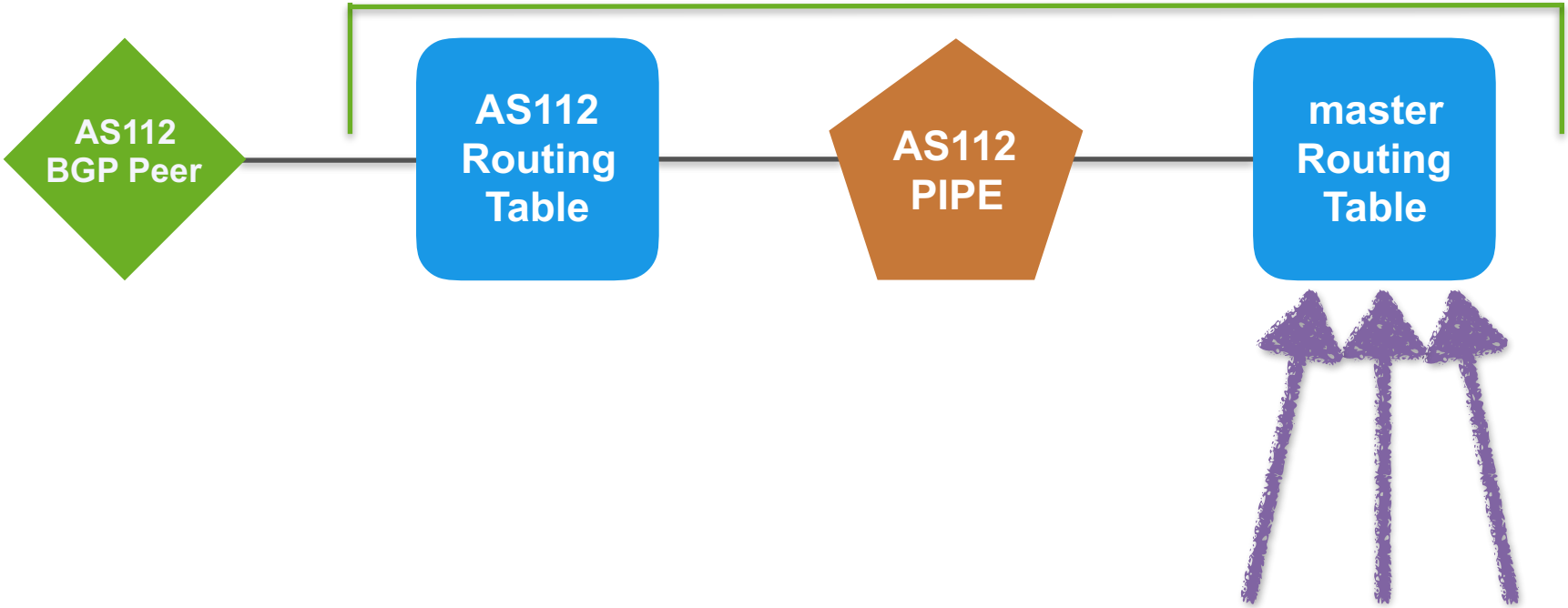
Pipe 'to master' filter filters all tagged prefixes

NEW ROUTE SERVERS

IXP Manager v5 Bird Topology - Export To Member

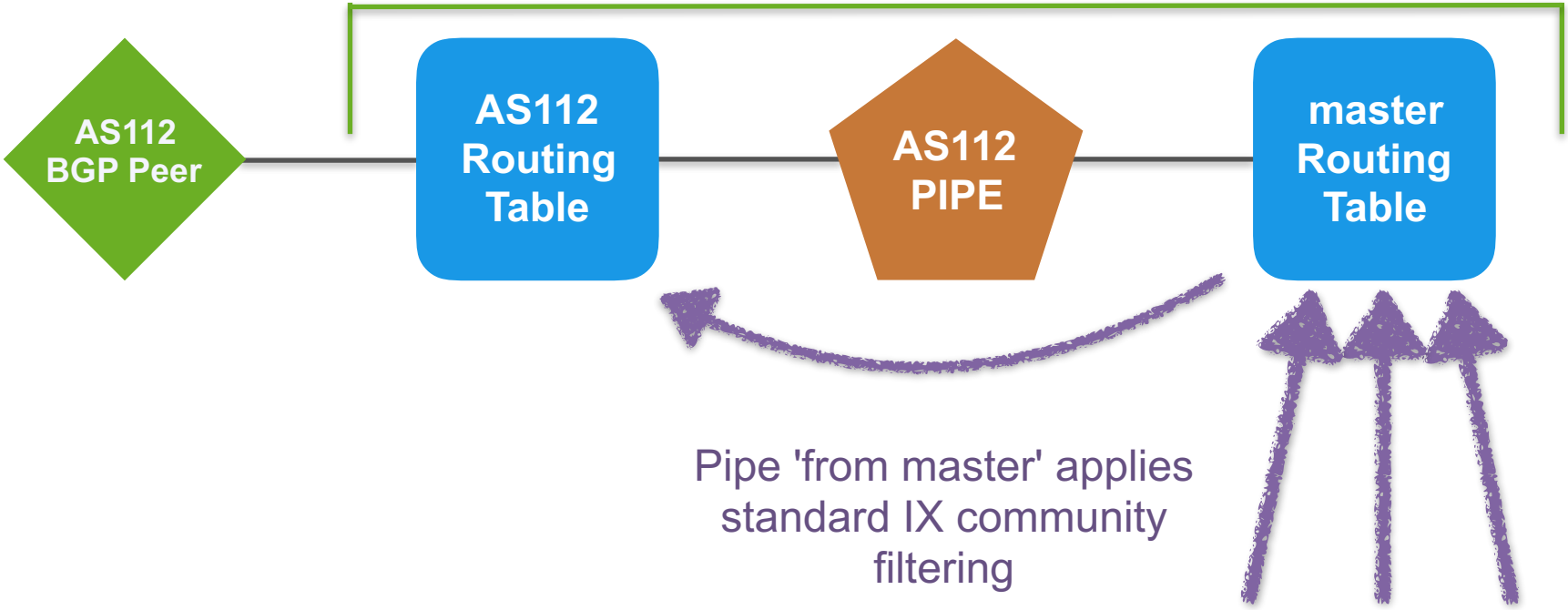
NEW ROUTE SERVERS

IXP Manager v5 Bird Topology - Export To Member



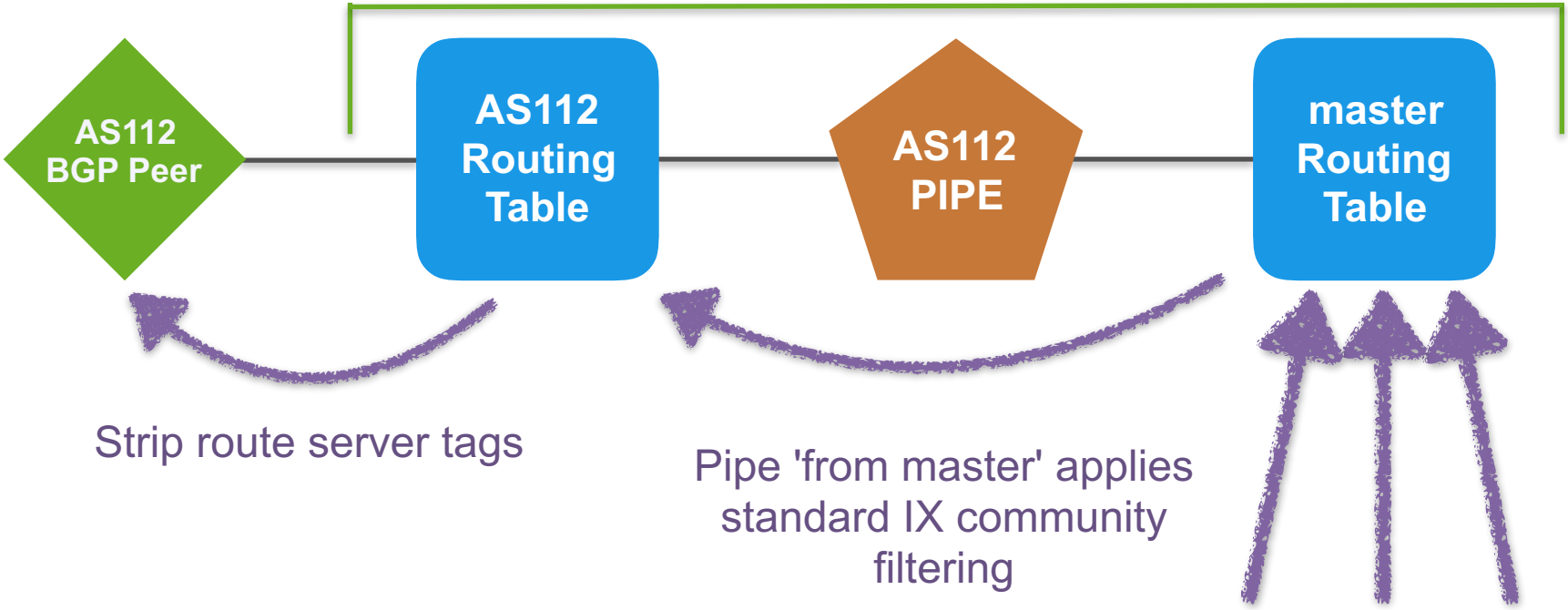
NEW ROUTE SERVERS

IXP Manager v5 Bird Topology - Export To Member



NEW ROUTE SERVERS

IXP Manager v5 Bird Topology - Export To Member



RPKI Implementation Notes

RPKI @ INEX

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 zxf 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 zxf rpki-rtr-server-latest-dist.tar.gz
$ ./rpki-rtr-server/rpki-rtr-server-3.sh
```

RPKI @ INEX

Validator Software - Routinator 3000

- Routinator 3000 by NLnet Labs
  - https://github.com/NLnetLabs/routinator
- First impressions: low overheard, 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
```

RPKI @ INEX

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
```

RPKI @ INEX

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

RPKI @ INEX

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.)

IXP MANAGER INEX Member Information Peering Statistics Support

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

IXP MANAGER INEX Member Information Peering Statistics Support

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

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 ⚠	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

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	[illegible]
BGP :: Large Communities	2128:1000:2 RPKI UNKNOWN 2128:1101:9 IRRDB PREFIX FILTERED 2128:1001:1001 IRRDB FILTERED STRICT

Close

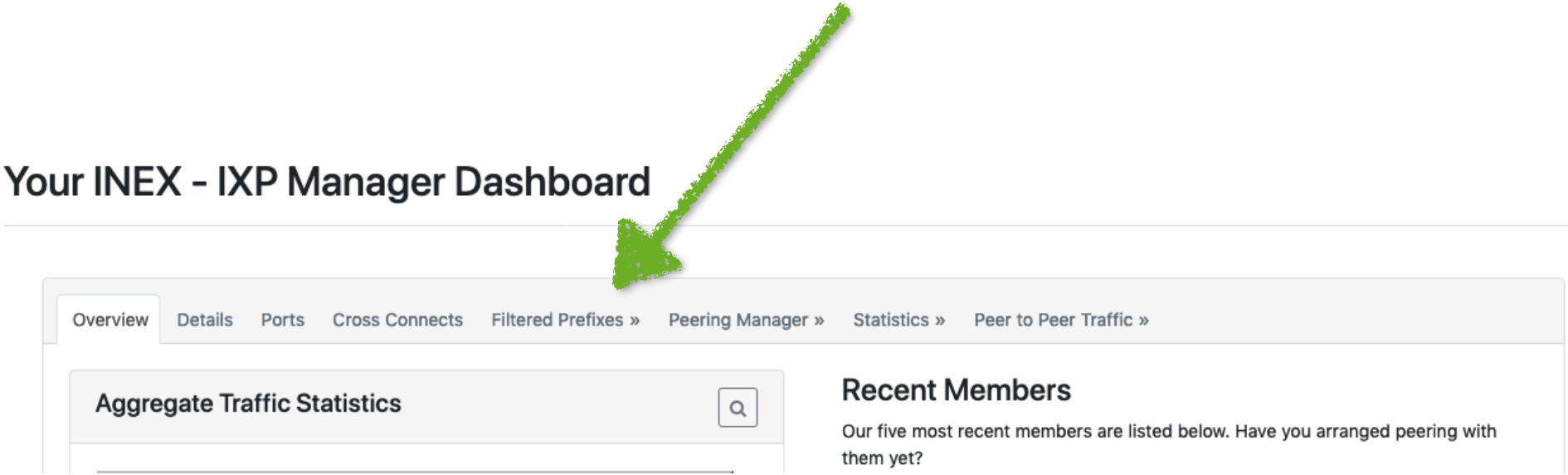
Network	Next Hop	Metric	Communities?	AS Path	
104.132.227.0/24	18				Details
109.125.0.0/18	18				Details
132.189.78.0/24	18				Details
132.189.79.0/24	18				Details
132.237.132.0/24	18				Details
132.237.167.0/24	18				Details
134.191.192.0/24	18				Details
134.191.216.0/22	18				Details
134.191.220.0/23	18				Details
134.191.240.0/22	18				Details
134.191.244.0/24	18				Details
134.191.246.0/23	18				Details
135.74.153.0/24	18				Details
146.214.64.0/23	18				Details
146.247.40.0/21	18				Details
159.134.0.0/16	18				Details
163.244.116.0/22	18				Details
163.244.12.0/22	18				Details
163.244.24.0/23	185.1.69.12	P 100	1 LC: 2	5466 30614	Details

RPKI @ INEX

New *Route Server Filtered Prefixes* Tool

RPKI @ INEX

New *Route Server Filtered Prefixes* Tool



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?

Barry O'Donovan
barry.odonovan@inex.ie
@barryo79

https://www.inex.ie/

@ComePeerWithMe