



# 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

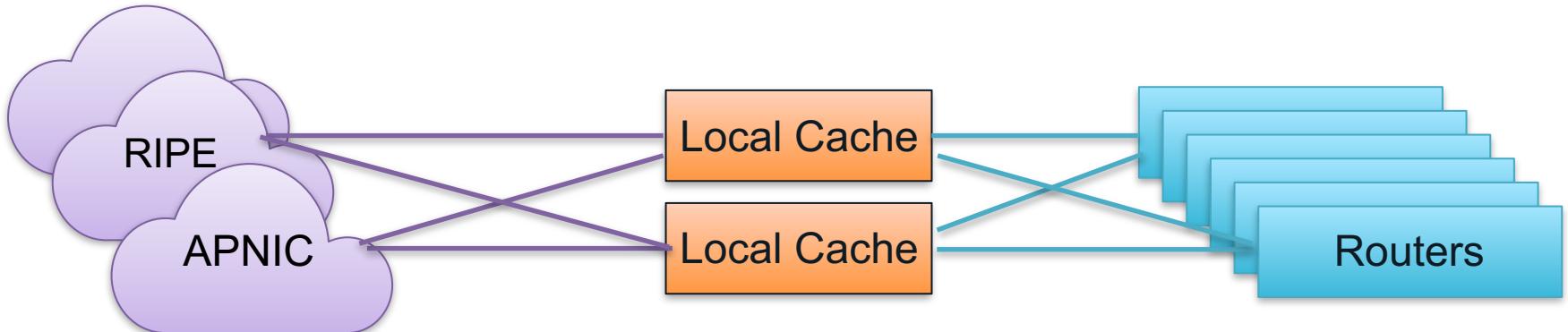
- A cryptographically secure replacement for route[6] objects
- Adds maximum prefix length
- Yields route origin triplets that have been validated

```
( 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



RPKI

## 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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# RIPE NCC

RIPE NETWORK COORDINATION CENTRE

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

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

RPKI

# 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		



## 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<sup>1</sup> 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 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

43760:1101:\* are filtered

*Side note*

## 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

# 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

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## NEW ROUTE SERVERS

# Filter Known Transit Networks

```

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

```

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

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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

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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

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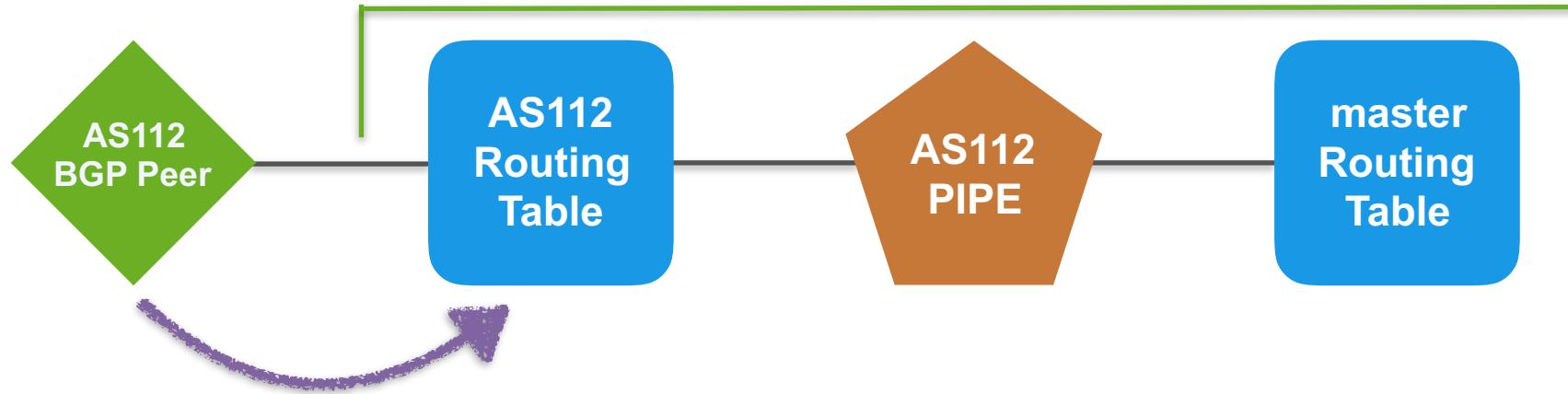
NEW ROUTE SERVERS

## IXP Manager v5 Bird Topology - Import From Member



NEW ROUTE SERVERS

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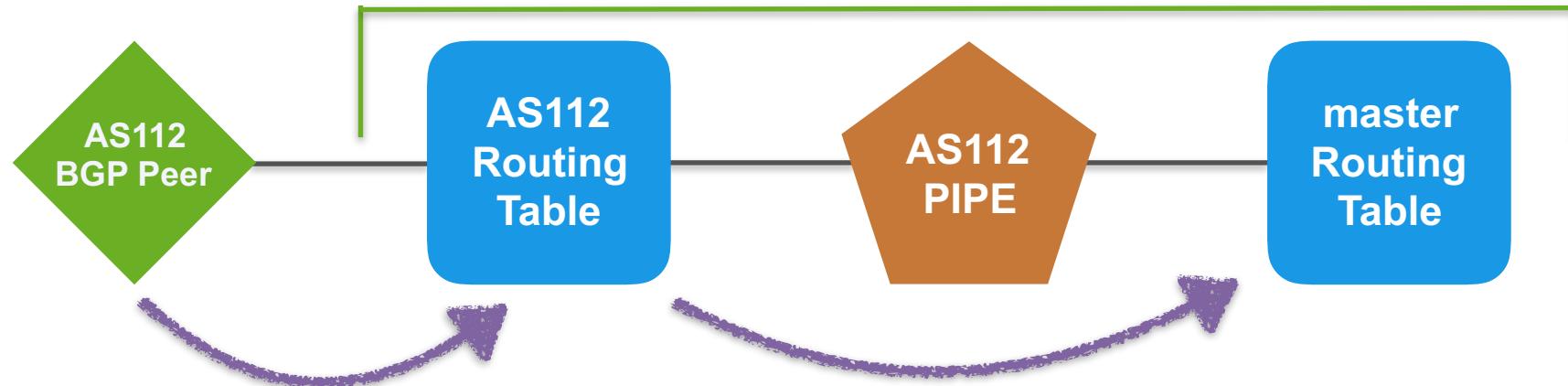


BGP import filter checks  
prefixes and tags for  
later filtering

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

NEW ROUTE SERVERS

## IXP Manager v5 Bird Topology - Import From Member

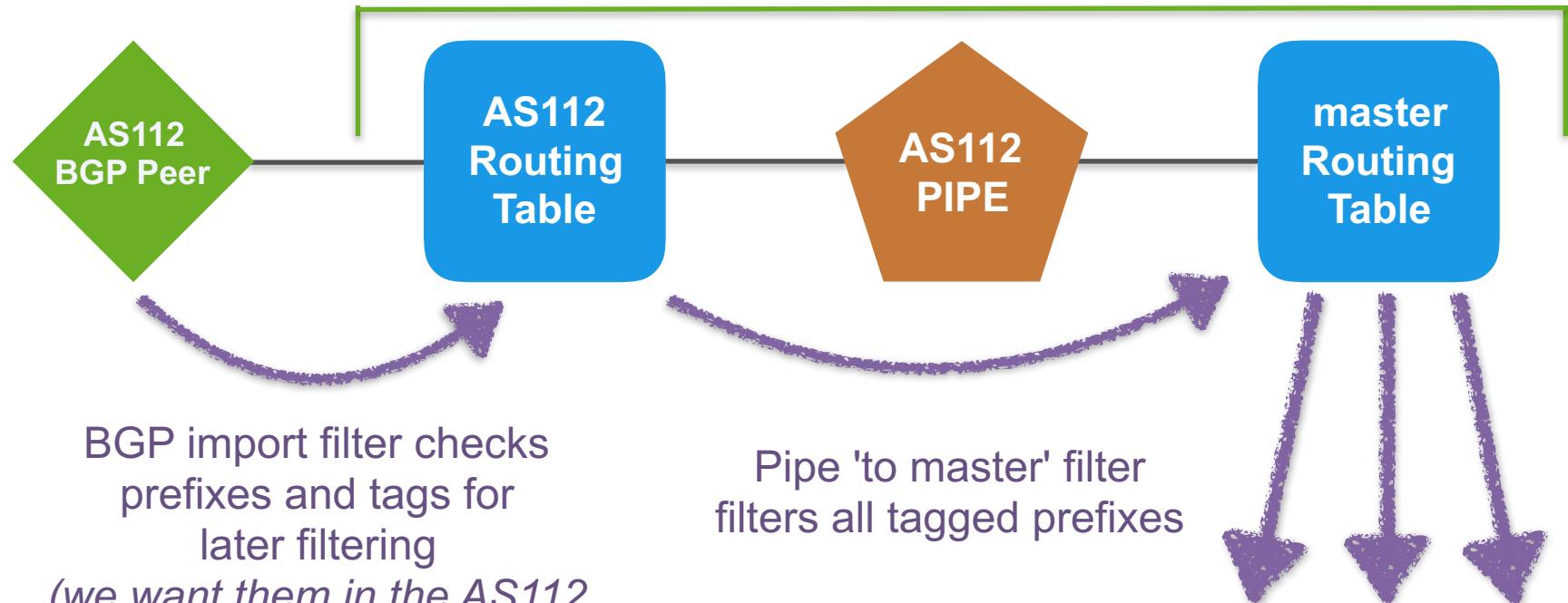


BGP import filter checks  
prefixes and tags for  
later filtering  
*(we want them in the AS112  
RT for the looking glass / analysis)*

Pipe 'to master' filter  
filters all tagged prefixes

NEW ROUTE SERVERS

## IXP Manager v5 Bird Topology - Import From Member



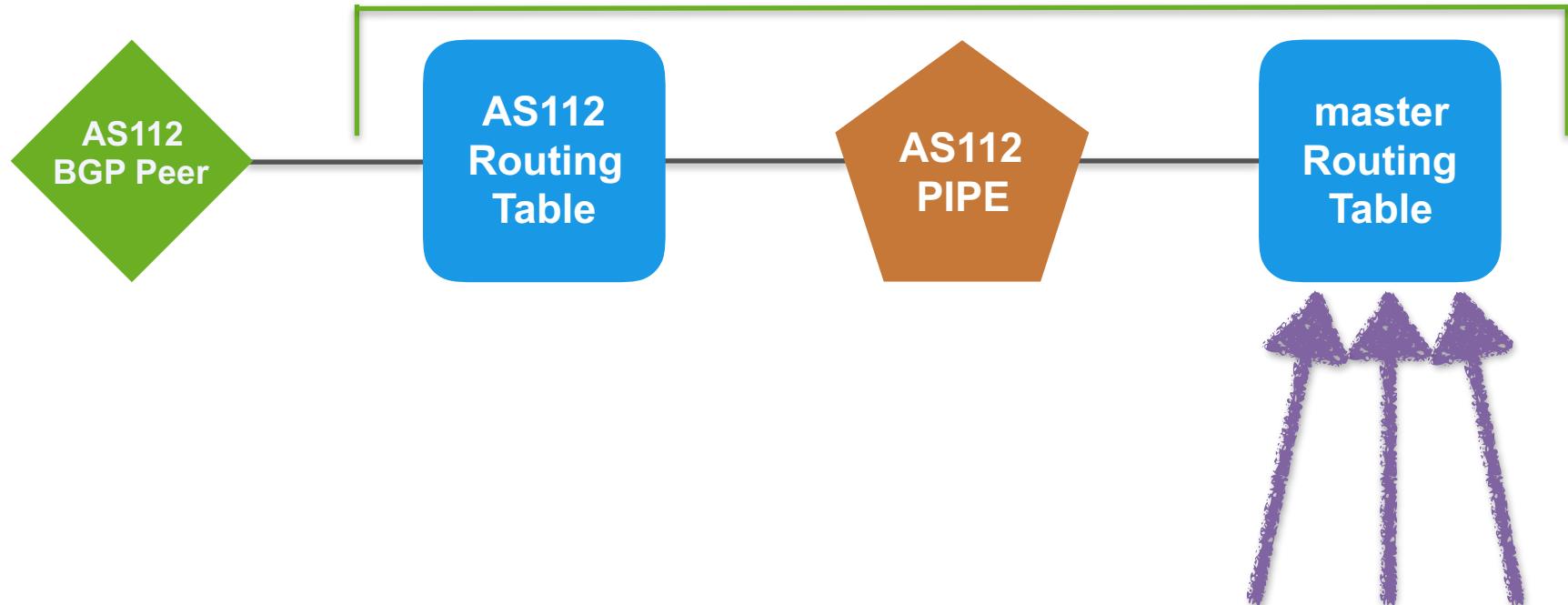
NEW ROUTE SERVERS

## IXP Manager v5 Bird Topology - Export To Member



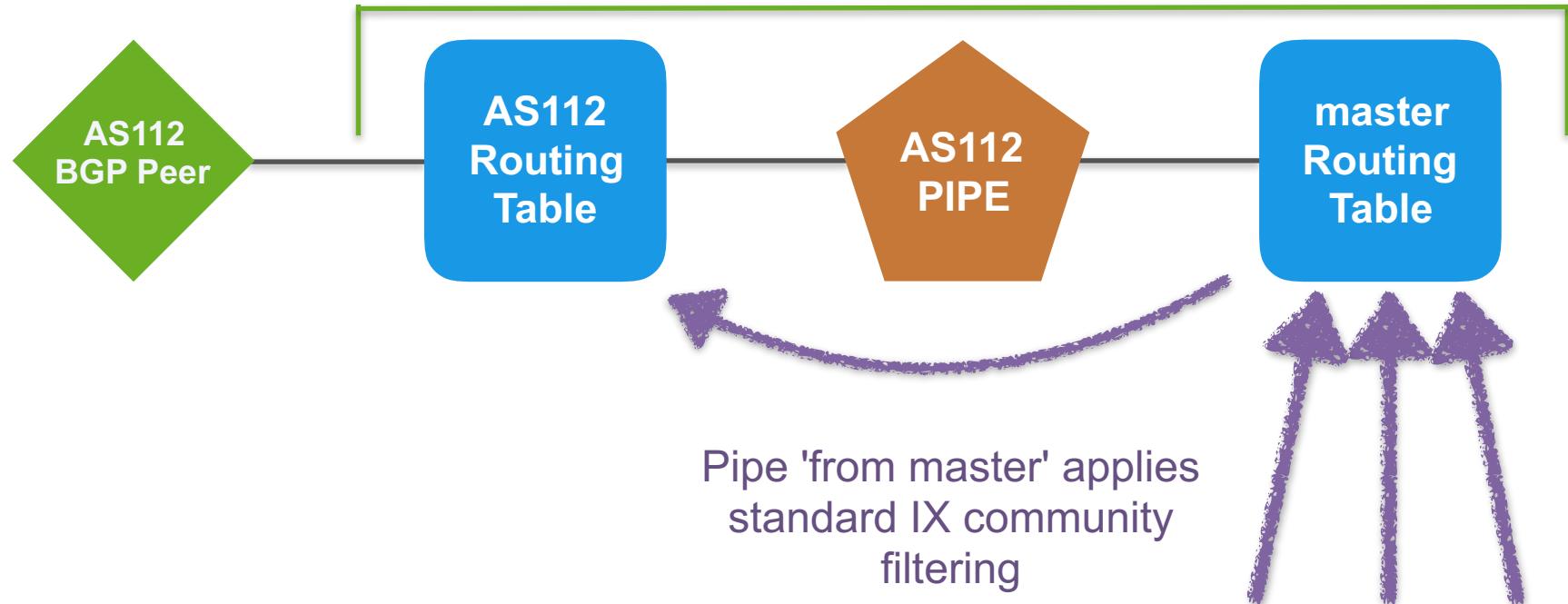
NEW ROUTE SERVERS

## IXP Manager v5 Bird Topology - Export To Member



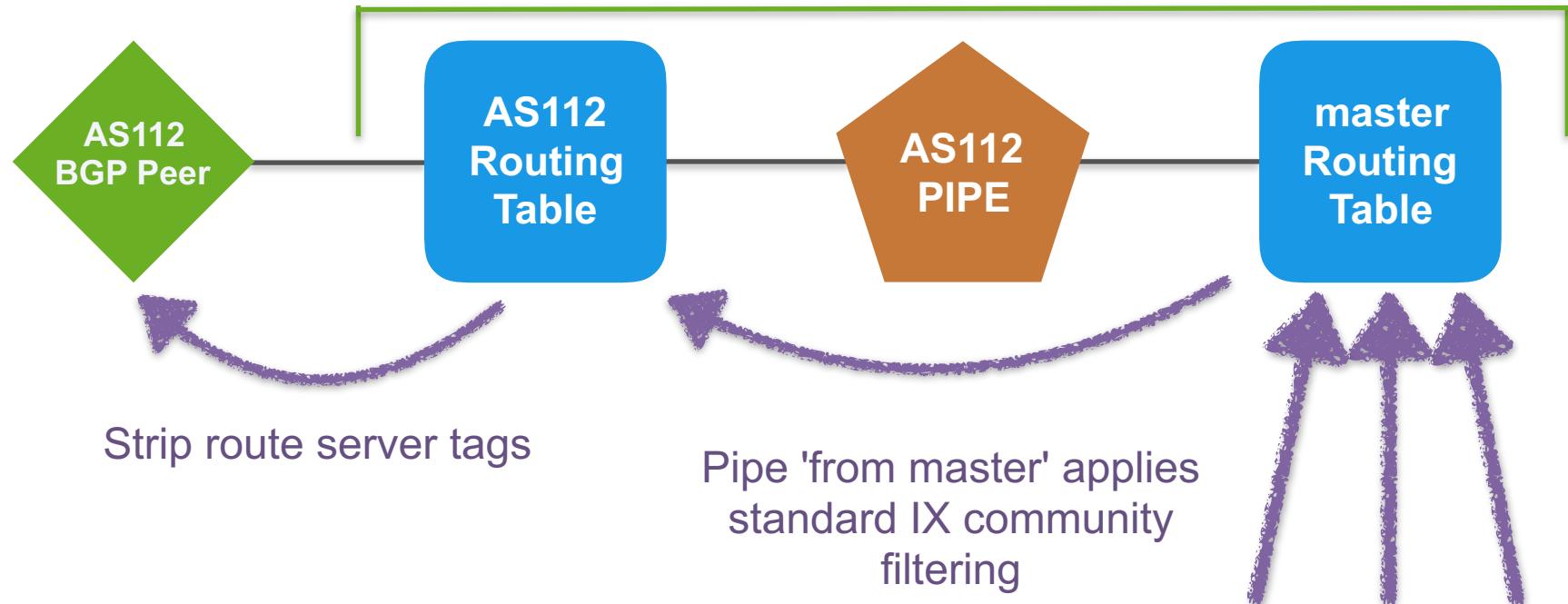
NEW ROUTE SERVERS

## 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 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
```

## 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 rpkil {

    roa4 { table t_roa; };

    remote "192.0.2.67" port 3323;

    retry keep 90;
    refresh keep 900;
    expire keep 172800;
}
```

## 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.)

# Looking Glass

 INEX Cork - Route Collector - IPv4INEX 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	<a href="#">Details</a>
185.1.69.24	AS714 – Apple Distribution International	714	master4		596	0	<a href="#">Details</a>
185.1.69.26	AS714 – Apple Distribution International	714	master4		597	0	<a href="#">Details</a>
185.1.69.11	AS1213 – HEAnet	1213	master4		23	0	<a href="#">Details</a>
185.1.69.12	AS5466 – Eir	5466	master4		77	0	<a href="#">Details</a>
185.1.69.17	AS15405 – East Cork Broadband	15405	master4		5	0	<a href="#">Details</a>
185.1.69.14	AS16171 – Strencom	16171	master4		4	0	<a href="#">Details</a>
185.1.69.16	AS20940 – Akamai Technologies	20940	master4		1	0	<a href="#">Details</a>
185.1.69.23	AS25152 – RIPE NCC k-root server	25152	master4		1	0	<a href="#">Details</a>
185.1.69.10	AS31122 – Viatel	31122	master4		90	0	<a href="#">Details</a>
185.1.69.19	AS41736 – Nova Telecom	41736	master4		3	0	<a href="#">Details</a>
185.1.69.21	AS42090 – Rapid Broadband	42090	master4		6	0	<a href="#">Details</a>

# Looking Glass

 INEX Cork - Route Collector - IPv4INEX Cork - Route Collector - IPv4 ▾  

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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	<button>Details</button>
185.1.69.24	AS714 – Apple Distribution International	714	master4		596	0	<button>Details</button>
185.1.69.26	AS714 – Apple Distribution International	714	master4		597	0	<button>Details</button>
185.1.69.11	AS1213 – HEAnet	1213	master4		23	0	<button>Details</button>
185.1.69.12	AS5466 – Eir	5466	master4		77	0	<button>Details</button>
185.1.69.17	AS15405 – East Cork Broadband	15405	master4		5	0	<button>Details</button>
185.1.69.14	AS16171 – Strencom	16171	master4		4	0	<button>Details</button>
185.1.69.16	AS20940 – Akamai Technologies	20940	master4		1	0	<button>Details</button>
185.1.69.23	AS25152 – RIPE NCC k-root server	25152	master4		1	0	<button>Details</button>
185.1.69.10	AS31122 – Viatel	31122	master4		90	0	<button>Details</button>
185.1.69.19	AS41736 – Nova Telecom	41736	master4		3	0	<button>Details</button>
185.1.69.21	AS42090 – Rapid Broadband	42090	master4		6	0	<button>Details</button>

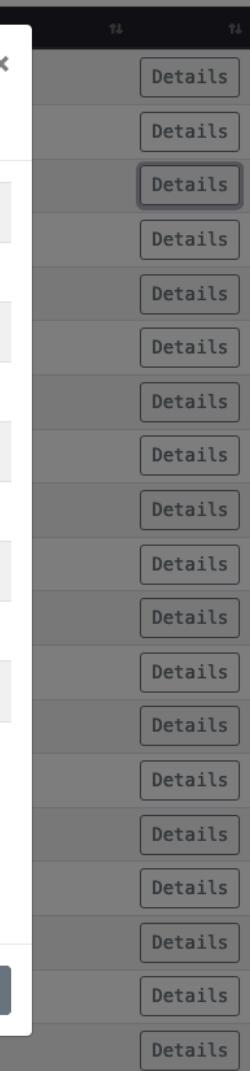
Network	Next Hop	Metric	Communities?	AS Path		
104.132.227.0/24	185.1.69.12	P 100	1 LC: 2	5466 41264		<button>Details</button>
109.125.0.0/18	185.1.69.12	P 100	1 LC: 2	5466 15751		<button>Details</button>
132.189.78.0/24	185.1.69.12	P 100	1 LC: 3 A	5466 8116		<button>Details</button>
132.189.79.0/24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

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

**Route Details - 132.189.78.0/24 as received from protocol pb\_as5466\_vli223\_ipv4**

<b>Network</b>	132.189.78.0/24
<b>Gateway</b>	185.1.69.12 <span style="border: 1px solid green; padding: 2px;">PRIMARY</span>
<b>From Protocol</b>	pb_as5466_vli223_ipv4
<b>Age</b>	2019-02-12 09:12:03
<b>Metric</b>	100
<b>Type</b>	BGP univ
<b>BGP :: AS Path</b>	5466 8116
<b>BGP :: Local Pref</b>	100
<b>BGP :: Communities</b>	5466:20
<b>BGP :: Large Communities</b>	2128:1000:2 <span style="background-color: #FFFFCC; border: 1px solid blue; padding: 2px;">RPKI UNKNOWN</span> 2128:1101:9 <span style="background-color: #FFFFCC; border: 1px solid red; padding: 2px;">IRRDB PREFIX FILTERED</span> 2128:1001:1001 <span style="background-color: #CCFFCC; border: 1px solid green; padding: 2px;">IRRDB FILTERED STRICT</span>
<b>159.134.0.0/16</b>	
<b>163.244.116.0/22</b>	
<b>163.244.12.0/22</b>	
<b>163.244.24.0/23</b>	185.1.69.12 <span style="border: 1px solid green; padding: 2px;">P</span> 100 <span style="border: 1px solid black; padding: 2px;">1 LC: 2</span> 5466 30614

**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?