The impact of an RPKI validator in Bangladesh and Lessons Learned

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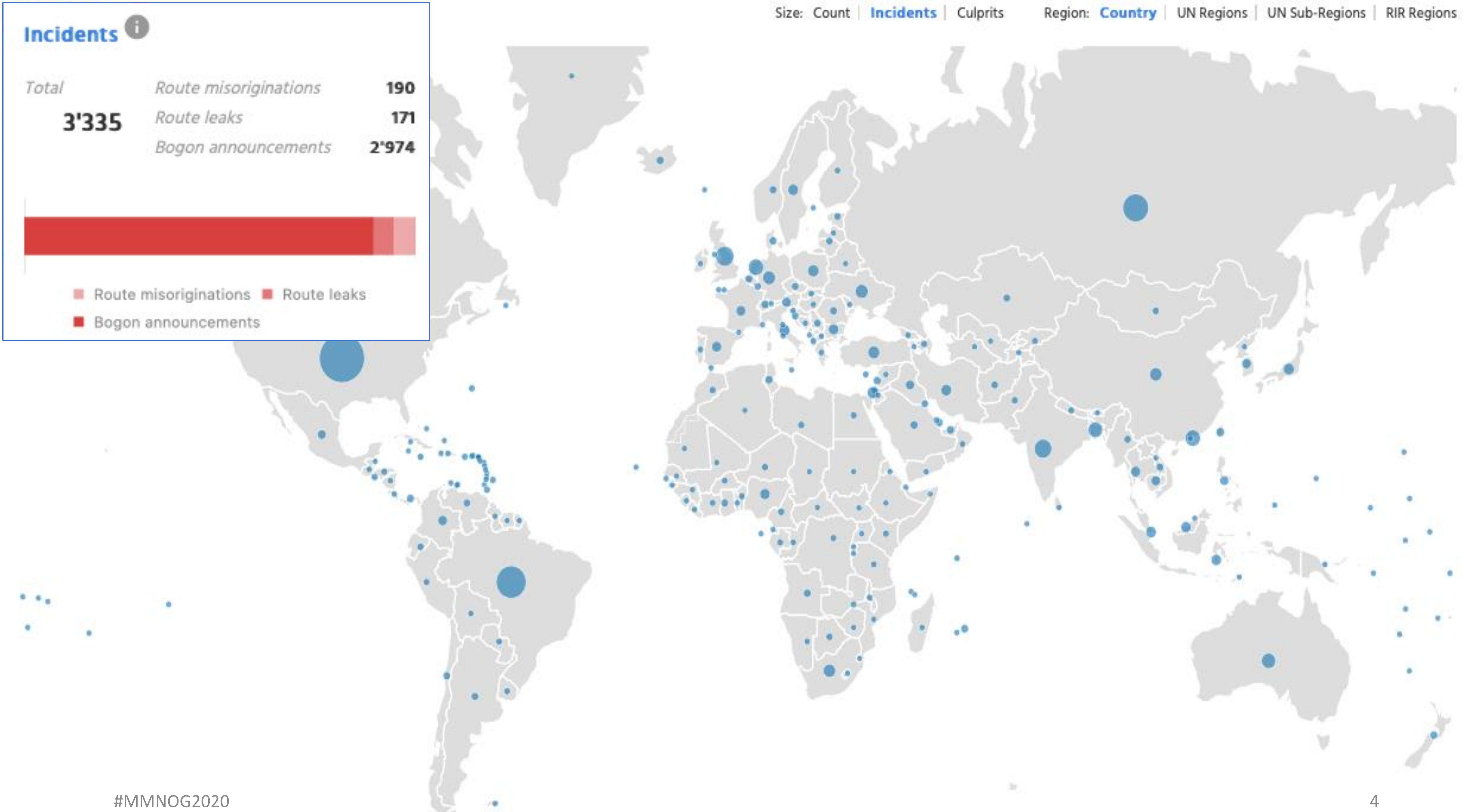
#MMNOG2020

Image source: Internet

Disclaimer

- We are talking about *ROUTING SECURITY;* it is NOT CYBERSECURITY or HOST VULNERABILITY or DATA LEAKAGE or any such concepts...
- Doing RPKI validation does not mean that without validation NDC was very vulnerable. Doing it provides additional routing security.
- The slide has information visible publicly. No confidential information of the NDC or any other organizations has been exposed here.
- The slides have screenshots that are not intended to promote or demote any ASN. It is used to show some real cases.

Starting with some routing incidents…



Size: Count | Incidents | Culprits
Region: Country | UN Regions | UN Sub-Regions | RIR Regions

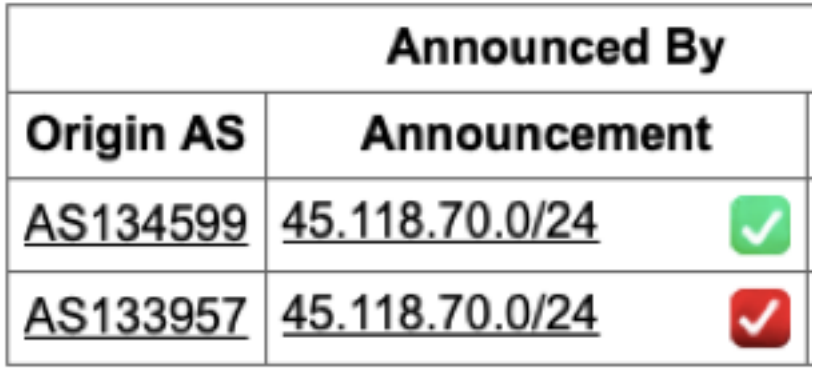
Incidents

Total		
3'335	*Route misoriginations*	190
	Route leaks	171
	Bogon announcements	2'974

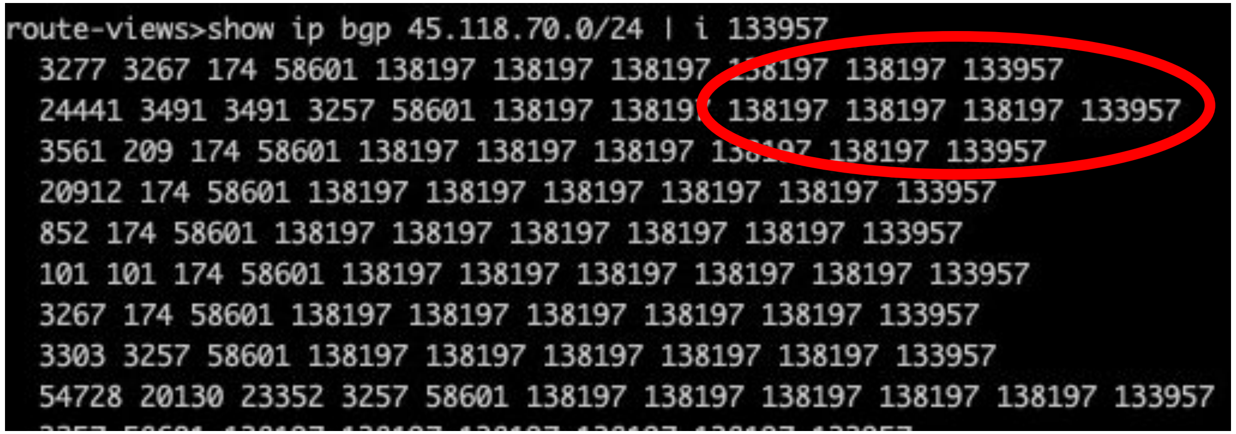
Route misoriginations
Route leaks
Bogon announcements

Source: https://observatory.manrs.org

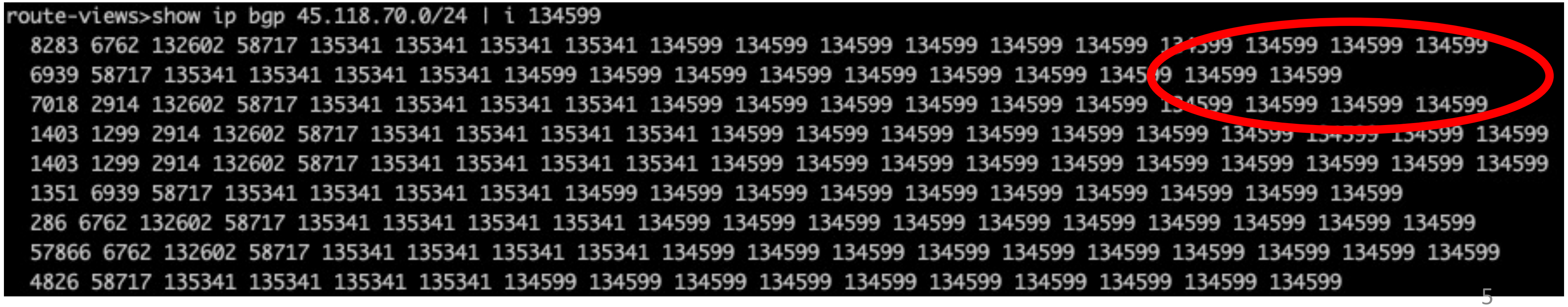
- A Prefix is announced by both AS 134599 and AS 133957 (might be unintentional)
- Either AS cloud be closest to different geographic locations
- Legitimate traffic might get blackholed



	Announced By	
Origin AS	Announcement	
AS134599	45.118.70.0/24	✅
AS133957	45.118.70.0/24	☑

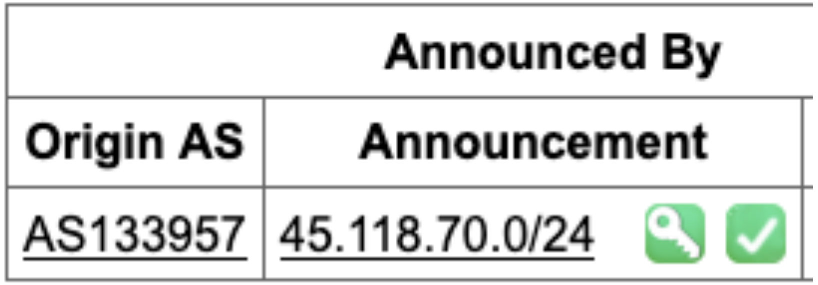


```
route-views>show ip bgp 45.118.70.0/24 | i 133957
  3277 3267 174 58601 138197 138197 138197 138197 138197 133957
  24441 3491 3491 3257 58601 138197 138197 138197 138197 138197 133957
  3561 209 174 58601 138197 138197 138197 138197 138197 133957
  20912 174 58601 138197 138197 138197 138197 138197 133957
  852 174 58601 138197 138197 138197 138197 138197 133957
  101 101 174 58601 138197 138197 138197 138197 138197 133957
  3267 174 58601 138197 138197 138197 138197 138197 133957
  3303 3257 58601 138197 138197 138197 138197 138197 133957
  54728 20130 23352 3257 58601 138197 138197 138197 138197 138197 133957
  3257 58601 138197 138197 138197 138197 138197 133957
```

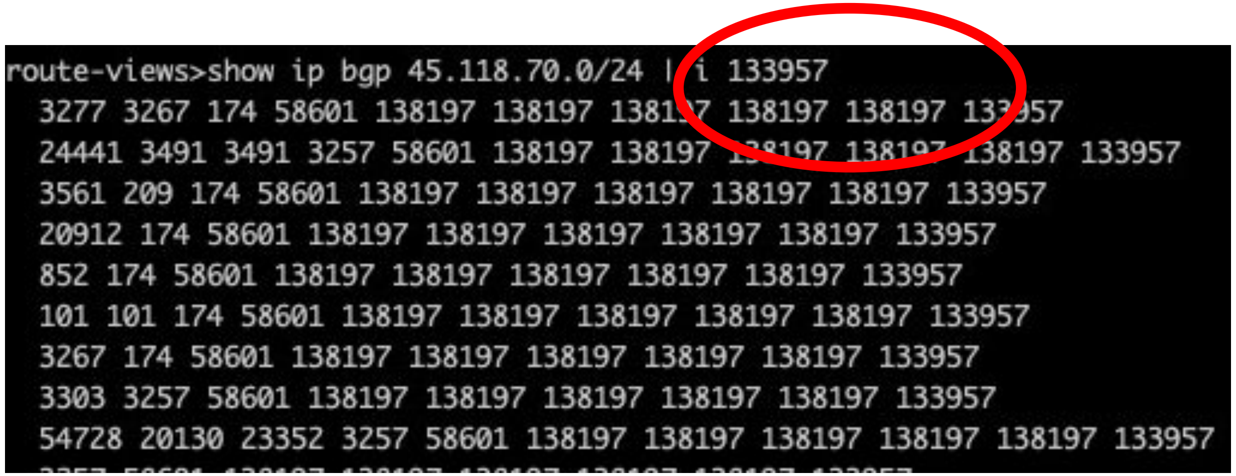


```
route-views>show ip bgp 45.118.70.0/24 | i 134599
  8283 6762 132602 58717 135341 135341 135341 135341 134599 134599 134599 134599 134599 134599 134599 134599 134599 134599
  6939 58717 135341 135341 135341 135341 134599 134599 134599 134599 134599 134599 134599 134599 134599 134599
  7018 2914 132602 58717 135341 135341 135341 135341 134599 134599 134599 134599 134599 134599 134599 134599 134599 134599
  1403 1299 2914 132602 58717 135341 135341 135341 135341 134599 134599 134599 134599 134599 134599 134599 134599 134599 134599
  1403 1299 2914 132602 58717 135341 135341 135341 135341 134599 134599 134599 134599 134599 134599 134599 134599 134599 134599
  1351 6939 58717 135341 135341 135341 135341 134599 134599 134599 134599 134599 134599 134599 134599 134599 134599
  286 6762 132602 58717 135341 135341 135341 135341 134599 134599 134599 134599 134599 134599 134599 134599 134599 134599
  57866 6762 132602 58717 135341 135341 135341 135341 134599 134599 134599 134599 134599 134599 134599 134599 134599 134599
  4826 58717 135341 135341 135341 135341 134599 134599 134599 134599 134599 134599 134599 134599 134599 134599
```

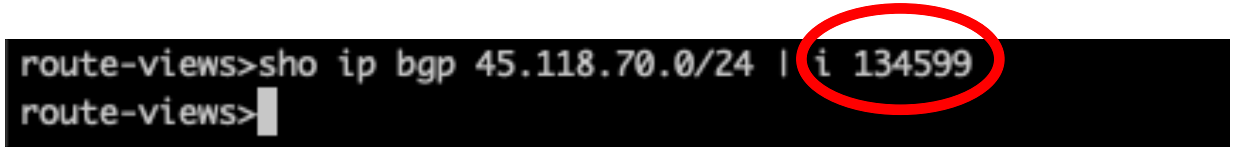
- Issue informed to the IP owner.
- They removed one announcement
- Created ROA for valid ASN
- Valid announcement visible in the global routing table



	Announced By
Origin AS	Announcement
AS133957	45.118.70.0/24 🔑 ✓

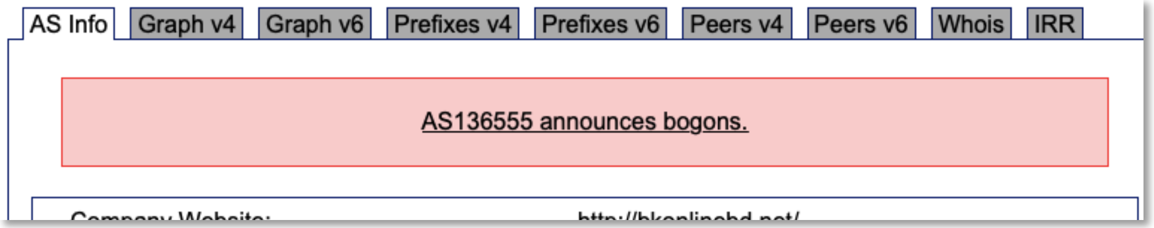


```
route-views>show ip bgp 45.118.70.0/24 | i 133957
  3277 3267 174 58601 138197 138197 138197 138197 138197 133957
  24441 3491 3491 3257 58601 138197 138197 138197 138197 138197 133957
  3561 209 174 58601 138197 138197 138197 138197 138197 133957
  20912 174 58601 138197 138197 138197 138197 138197 133957
  852 174 58601 138197 138197 138197 138197 138197 133957
  101 101 174 58601 138197 138197 138197 138197 138197 133957
  3267 174 58601 138197 138197 138197 138197 138197 133957
  3303 3257 58601 138197 138197 138197 138197 138197 133957
  54728 20130 23352 3257 58601 138197 138197 138197 138197 138197 133957
  3257 58601 138197 138197 138197 138197 138197 133957
```



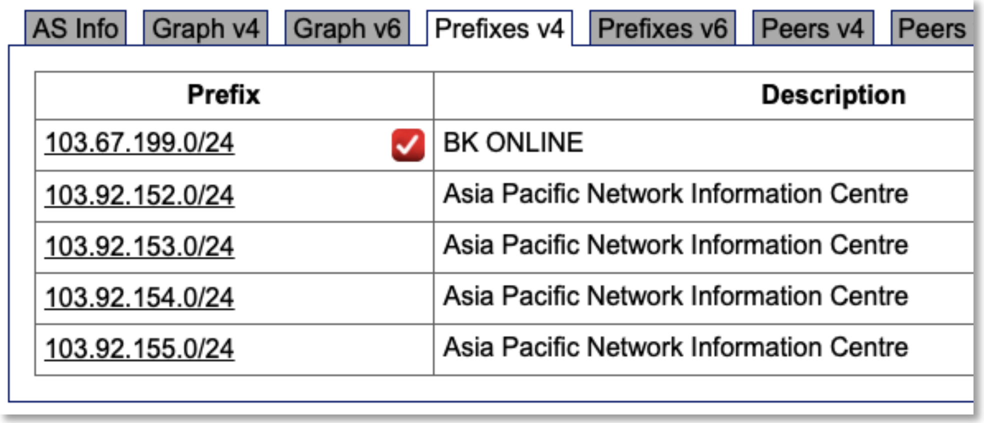
```
route-views>sho ip bgp 45.118.70.0/24 | i 134599
route-views>
```

- Client AS didn’t update APNIC membership
- Shouldn’t have valid prefix allocation with revoked membership
- Transit still announces client’s prefixes
- Prefixes marked as BOGON in global routing table

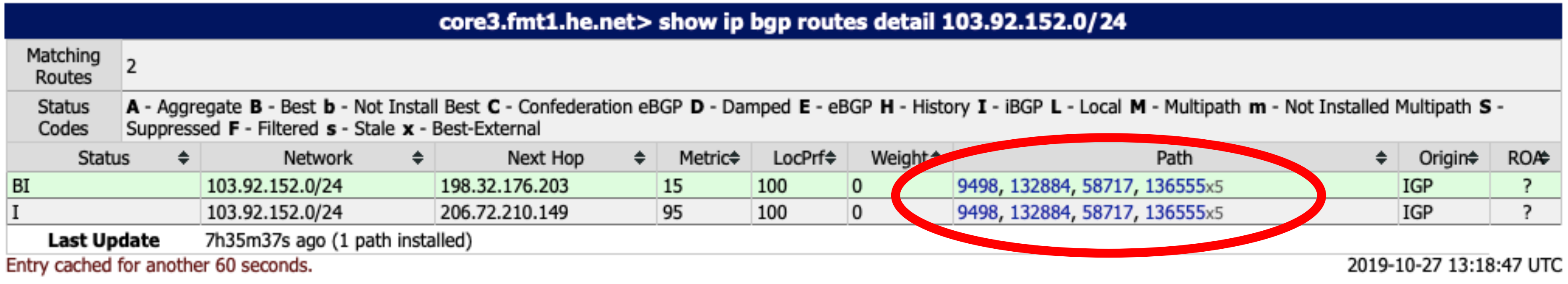


AS136555 announces bogons.

Company Website: http://bkonlinebd.net/



Prefix	Description
103.67.199.0/24 ✓	BK ONLINE
103.92.152.0/24	Asia Pacific Network Information Centre
103.92.153.0/24	Asia Pacific Network Information Centre
103.92.154.0/24	Asia Pacific Network Information Centre
103.92.155.0/24	Asia Pacific Network Information Centre



core3.fmt1.he.net> show ip bgp routes detail 103.92.152.0/24

Matching Routes	2
Status Codes	**A** - Aggregate **B** - Best **b** - Not Install Best **C** - Confederation eBGP **D** - Damped **E** - eBGP **H** - History **I** - iBGP **L** - Local **M** - Multipath **m** - Not Installed Multipath **S** - Suppressed **F** - Filtered **s** - Stale **x** - Best-External

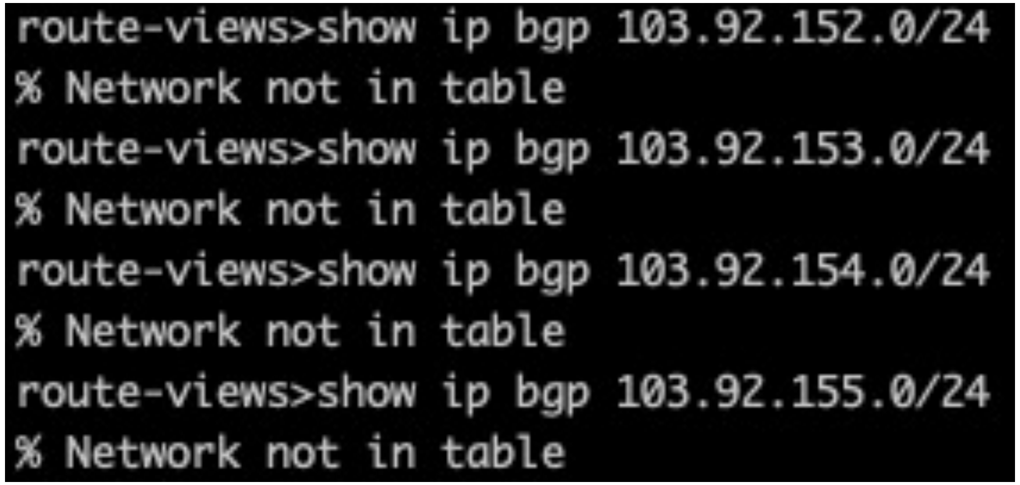
Status	Network	Next Hop	Metric	LocPrf	Weight	Path	Origin	ROA
BI	103.92.152.0/24	198.32.176.203	15	100	0	9498, 132884, 58717, 136555x5	IGP	?
I	103.92.152.0/24	206.72.210.149	95	100	0	9498, 132884, 58717, 136555x5	IGP	?

Last Update 7h35m37s ago (1 path installed)

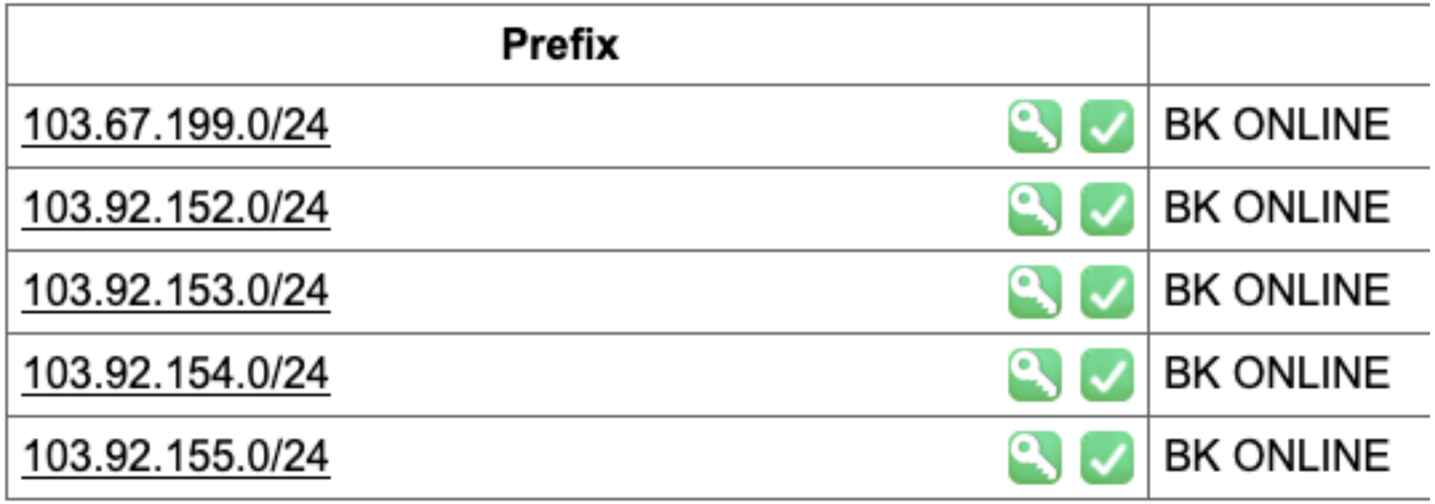
Entry cached for another 60 seconds.

2019-10-27 13:18:47 UTC

- The issue has been informed to the transit provider
- Then, they dropped it
- The announcement was removed from global table
- Later on, the AS got membership renewed and has its allocated prefixes back for use

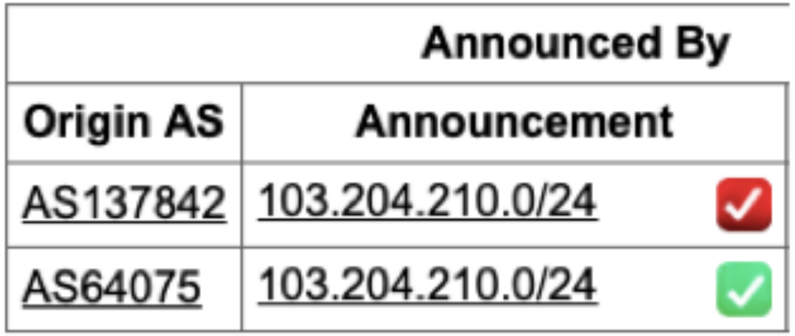


```
route-views>show ip bgp 103.92.152.0/24
% Network not in table
route-views>show ip bgp 103.92.153.0/24
% Network not in table
route-views>show ip bgp 103.92.154.0/24
% Network not in table
route-views>show ip bgp 103.92.155.0/24
% Network not in table
```

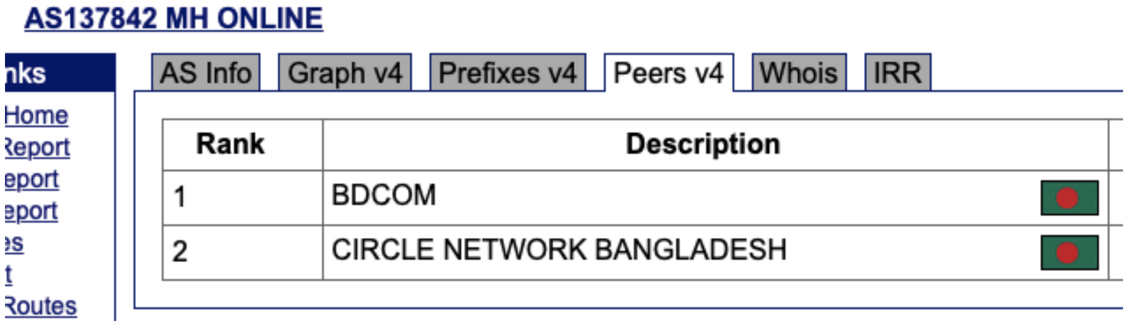


Prefix		
103.67.199.0/24	🔑 ✓	BK ONLINE
103.92.152.0/24	🔑 ✓	BK ONLINE
103.92.153.0/24	🔑 ✓	BK ONLINE
103.92.154.0/24	🔑 ✓	BK ONLINE
103.92.155.0/24	🔑 ✓	BK ONLINE

- AS 64075 delegated its prefix 103.204.210.0/24 to AS 137842
- AS 137842 announced the prefix
- AS 64075 is also announcing its delegated prefixes as AS 137842 (AS Hijack)
- It’s upstream accepting it and further announcing it globally

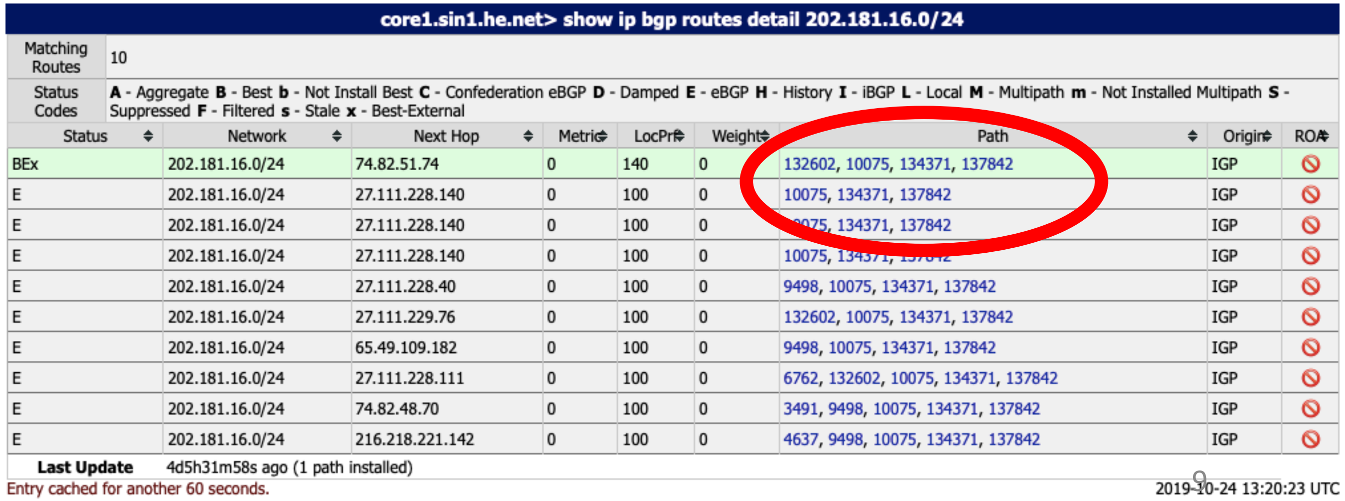


Announced By	
Origin AS	Announcement
AS137842	103.204.210.0/24 ☒
AS64075	103.204.210.0/24 ✓



AS137842 MH ONLINE

Rank	Description
1	BDCOM
2	CIRCLE NETWORK BANGLADESH



core1.sin1.he.net> show ip bgp routes detail 202.181.16.0/24

Matching Routes: 10

Status Codes: **A** - Aggregate **B** - Best **b** - Not Install Best **C** - Confederation eBGP **D** - Damped **E** - eBGP **H** - History **I** - iBGP **L** - Local **M** - Multipath **m** - Not Installed Multipath **S** - Suppressed **F** - Filtered **s** - Stale **x** - Best-External

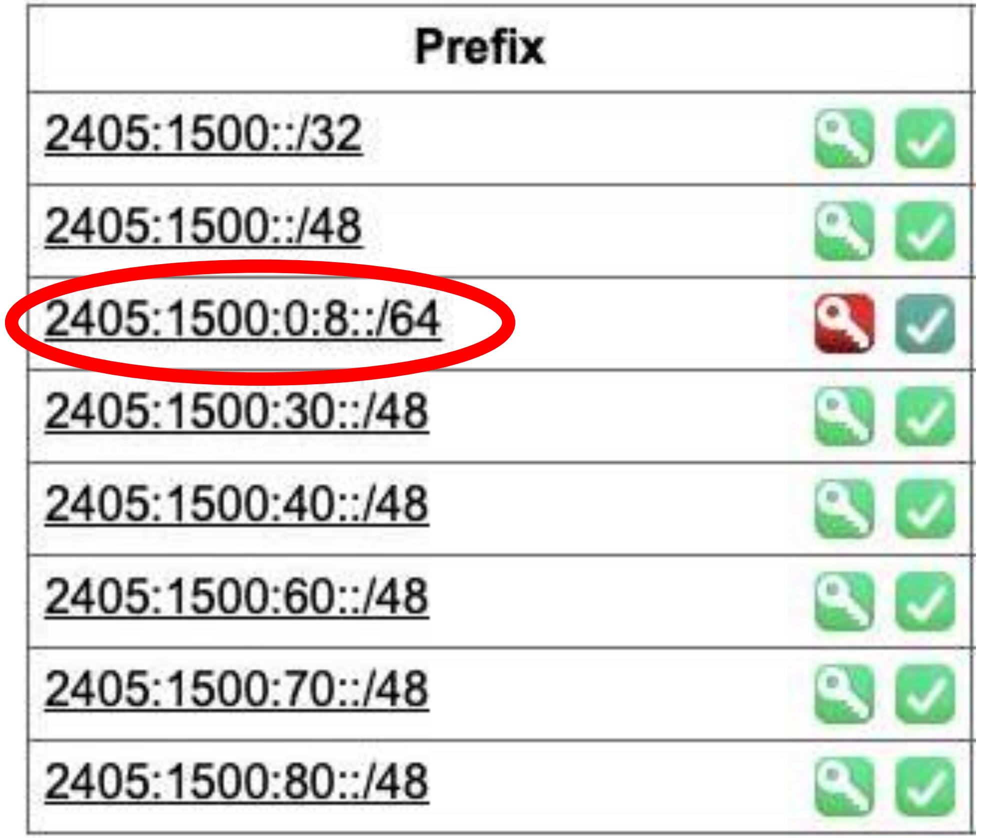
Status	Network	Next Hop	Metric	LocPrf	Weight	Path	Origin	ROA
BEx	202.181.16.0/24	74.82.51.74	0	140	0	132602, 10075, 134371, 137842	IGP	⃠
E	202.181.16.0/24	27.111.228.140	0	100	0	10075, 134371, 137842	IGP	⃠
E	202.181.16.0/24	27.111.228.140	0	100	0	10075, 134371, 137842	IGP	⃠
E	202.181.16.0/24	27.111.228.140	0	100	0	10075, 134371, 137842	IGP	⃠
E	202.181.16.0/24	27.111.228.40	0	100	0	9498, 10075, 134371, 137842	IGP	⃠
E	202.181.16.0/24	27.111.229.76	0	100	0	132602, 10075, 134371, 137842	IGP	⃠
E	202.181.16.0/24	65.49.109.182	0	100	0	9498, 10075, 134371, 137842	IGP	⃠
E	202.181.16.0/24	27.111.228.111	0	100	0	6762, 132602, 10075, 134371, 137842	IGP	⃠
E	202.181.16.0/24	74.82.48.70	0	100	0	3491, 9498, 10075, 134371, 137842	IGP	⃠
E	202.181.16.0/24	216.218.221.142	0	100	0	4637, 9498, 10075, 134371, 137842	IGP	⃠

Last Update 4d5h31m58s ago (1 path installed)

Entry cached for another 60 seconds.

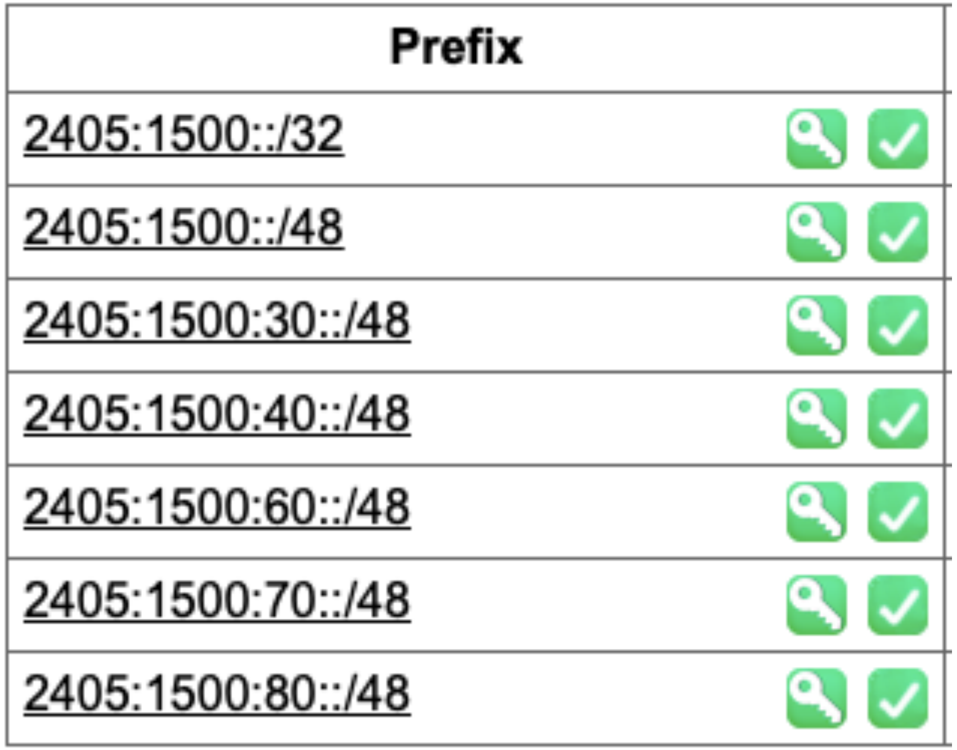
2019-10-24 13:20:23 UTC

- A /64 IPv6 prefix announced in global routing table
- Most specific announcement in global table is /48
- A /64 should never be in global routing table



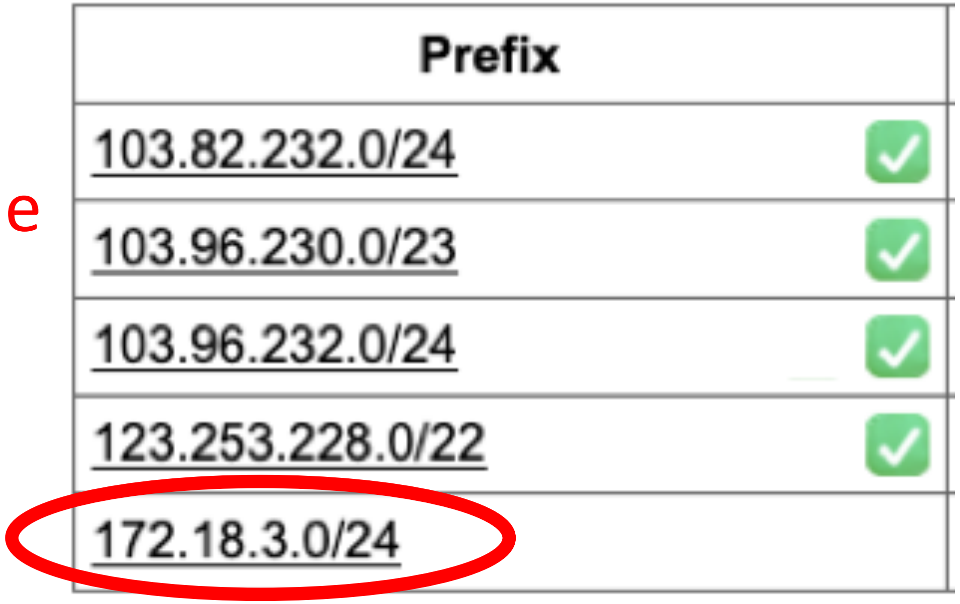
Prefix	
2405:1500::/32	🔑 ✓
2405:1500::/48	🔑 ✓
2405:1500:0:8::/64	🔑 ✓
2405:1500:30::/48	🔑 ✓
2405:1500:40::/48	🔑 ✓
2405:1500:60::/48	🔑 ✓
2405:1500:70::/48	🔑 ✓
2405:1500:80::/48	🔑 ✓

- The issue was informed to the AS
- The announcement has been removed

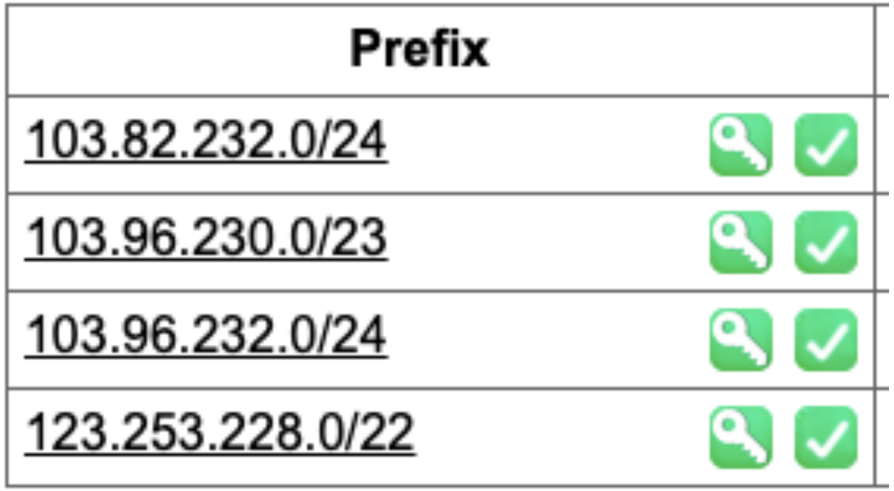


Prefix		
2405:1500::/32	🔑	✓
2405:1500::/48	🔑	✓
2405:1500:30::/48	🔑	✓
2405:1500:40::/48	🔑	✓
2405:1500:60::/48	🔑	✓
2405:1500:70::/48	🔑	✓
2405:1500:80::/48	🔑	✓

Somebody is announcing non-routable prefixes in the global BGP table.



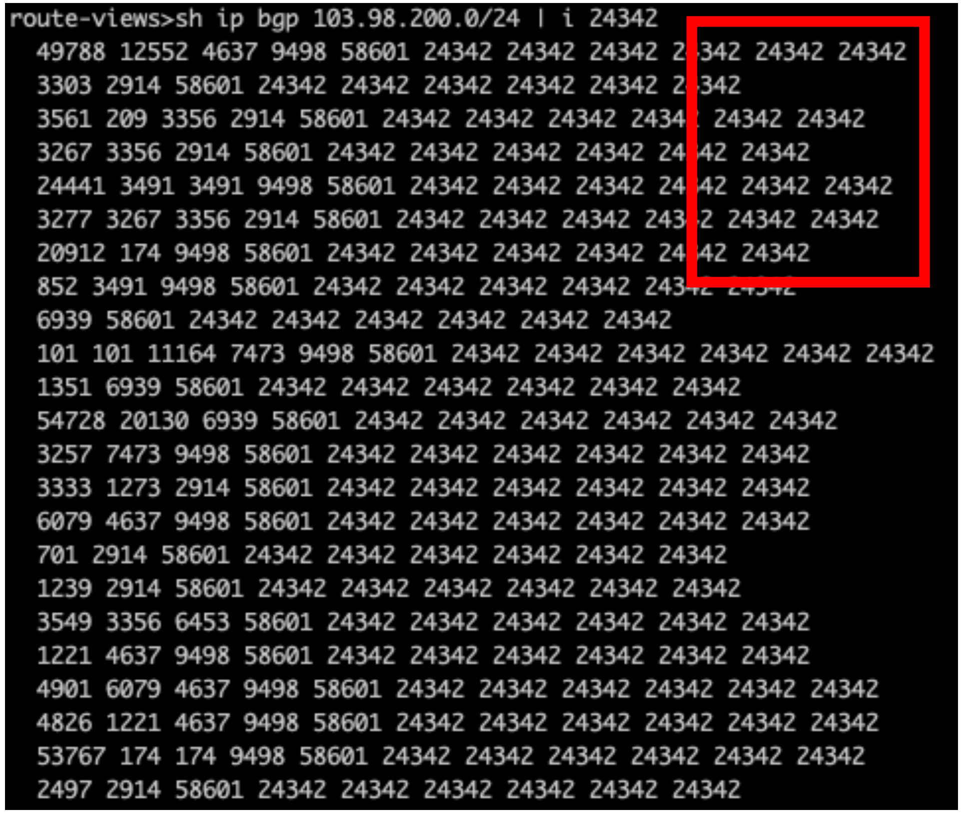
Prefix
103.82.232.0/24 ✓
103.96.230.0/23 ✓
103.96.232.0/24 ✓
123.253.228.0/22 ✓
172.18.3.0/24



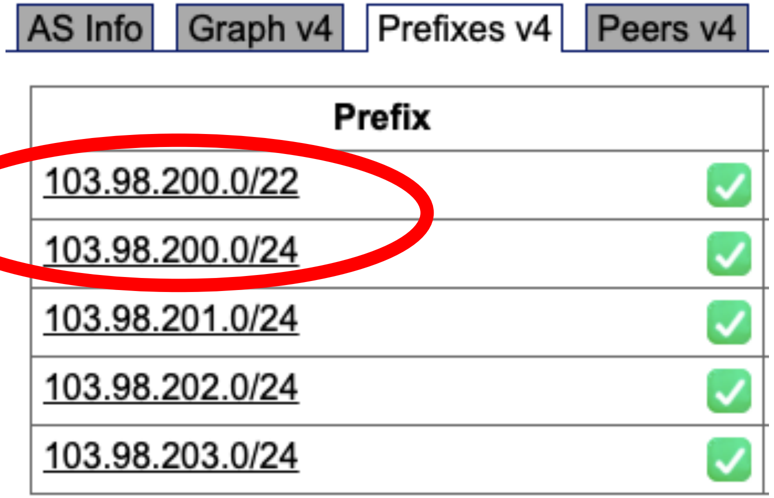
Prefix
103.82.232.0/24 🔑 ✓
103.96.230.0/23 🔑 ✓
103.96.232.0/24 🔑 ✓
123.253.228.0/22 🔑 ✓

The announcement has been removed once the issue was informed to them

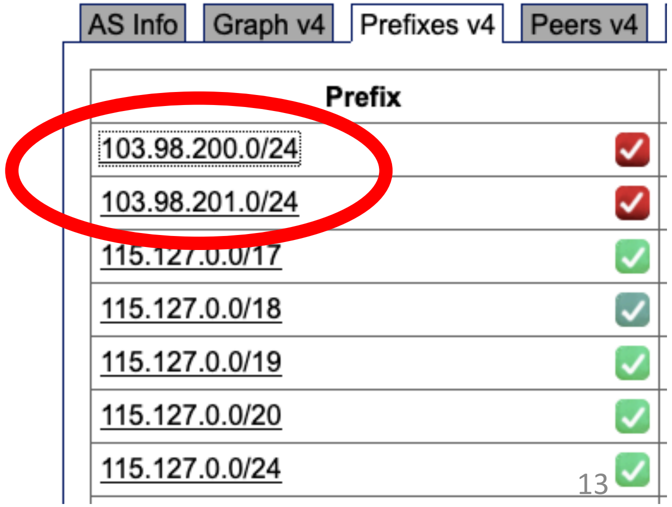
- Previously, AS 136909 used transit from AS 24342 using static routing.
- AS 24342 announced prefixes of AS 136909 in global BGP table on their behalf.
- Later, AS 136909 stated doing BGP but AS 24342 still didn't stop the announcement.



```
route-views>sh ip bgp 103.98.200.0/24 | i 24342
  49788 12552 4637 9498 58601 24342 24342 24342 24342 24342 24342
  3303 2914 58601 24342 24342 24342 24342 24342 24342
  3561 209 3356 2914 58601 24342 24342 24342 24342 24342 24342
  3267 3356 2914 58601 24342 24342 24342 24342 24342 24342
  24441 3491 3491 9498 58601 24342 24342 24342 24342 24342 24342
  3277 3267 3356 2914 58601 24342 24342 24342 24342 24342 24342
  20912 174 9498 58601 24342 24342 24342 24342 24342 24342
  852 3491 9498 58601 24342 24342 24342 24342 24342 24342
  6939 58601 24342 24342 24342 24342 24342 24342
  101 101 11164 7473 9498 58601 24342 24342 24342 24342 24342 24342
  1351 6939 58601 24342 24342 24342 24342 24342 24342
  54728 20130 6939 58601 24342 24342 24342 24342 24342 24342
  3257 7473 9498 58601 24342 24342 24342 24342 24342 24342
  3333 1273 2914 58601 24342 24342 24342 24342 24342 24342
  6079 4637 9498 58601 24342 24342 24342 24342 24342 24342
  701 2914 58601 24342 24342 24342 24342 24342 24342
  1239 2914 58601 24342 24342 24342 24342 24342 24342
  3549 3356 6453 58601 24342 24342 24342 24342 24342 24342
  1221 4637 9498 58601 24342 24342 24342 24342 24342 24342
  4901 6079 4637 9498 58601 24342 24342 24342 24342 24342 24342
  4826 1221 4637 9498 58601 24342 24342 24342 24342 24342 24342
  53767 174 174 9498 58601 24342 24342 24342 24342 24342 24342
  2497 2914 58601 24342 24342 24342 24342 24342 24342
```

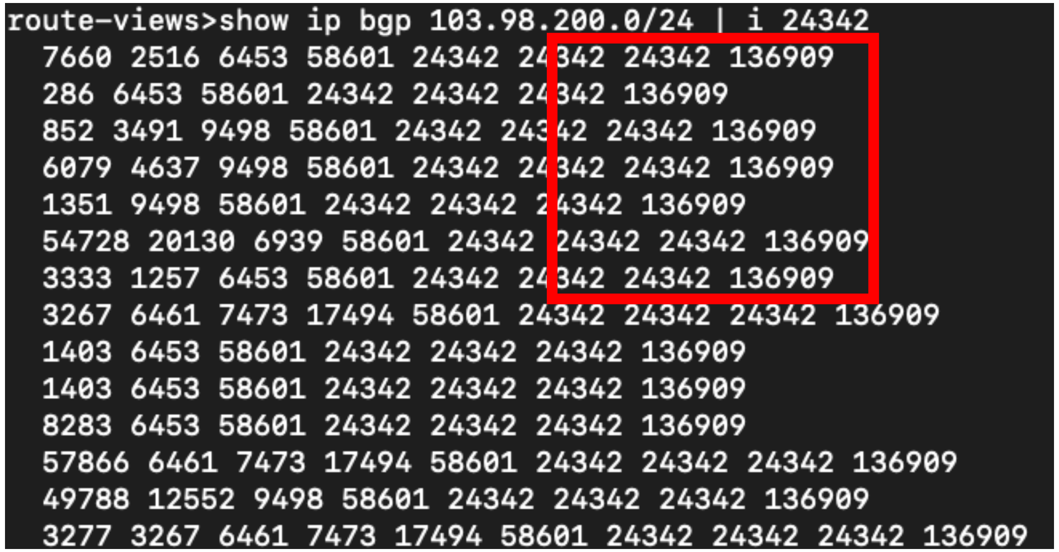


Prefix	
103.98.200.0/22	✓
103.98.200.0/24	✓
103.98.201.0/24	✓
103.98.202.0/24	✓
103.98.203.0/24	✓

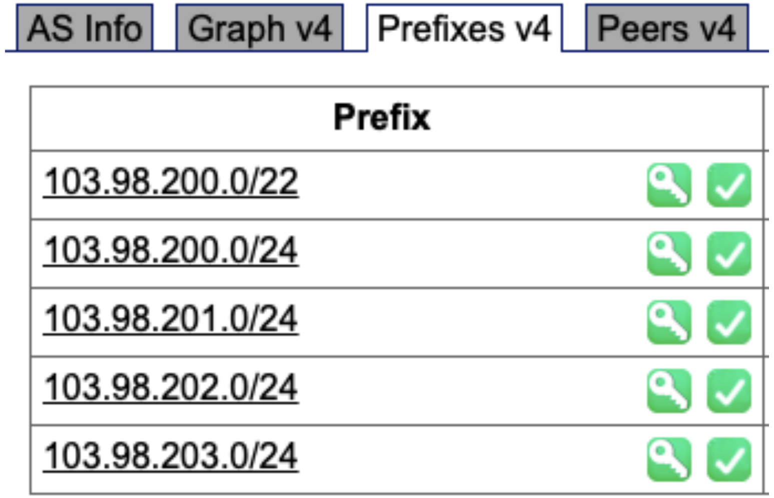


Prefix	
103.98.200.0/24	✓
103.98.201.0/24	✓
115.127.0.0/17	✓
115.127.0.0/18	✓
115.127.0.0/19	✓
115.127.0.0/20	✓
115.127.0.0/24	✓

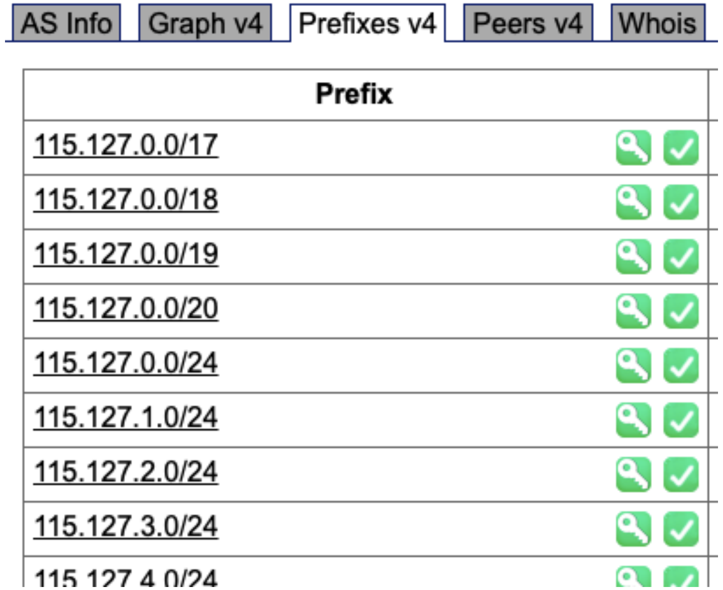
- AS 24342 has been informed to stop announcing client's prefixes
- Client AS 136909 has signed their prefixes
- Issue resolved.



```
route-views>show ip bgp 103.98.200.0/24 | i 24342
  7660 2516 6453 58601 24342 24342 24342 136909
  286 6453 58601 24342 24342 24342 136909
  852 3491 9498 58601 24342 24342 24342 136909
  6079 4637 9498 58601 24342 24342 24342 136909
  1351 9498 58601 24342 24342 24342 136909
  54728 20130 6939 58601 24342 24342 24342 136909
  3333 1257 6453 58601 24342 24342 24342 136909
  3267 6461 7473 17494 58601 24342 24342 24342 136909
  1403 6453 58601 24342 24342 24342 136909
  1403 6453 58601 24342 24342 24342 136909
  8283 6453 58601 24342 24342 24342 136909
  57866 6461 7473 17494 58601 24342 24342 24342 136909
  49788 12552 9498 58601 24342 24342 24342 136909
  3277 3267 6461 7473 17494 58601 24342 24342 24342 136909
```

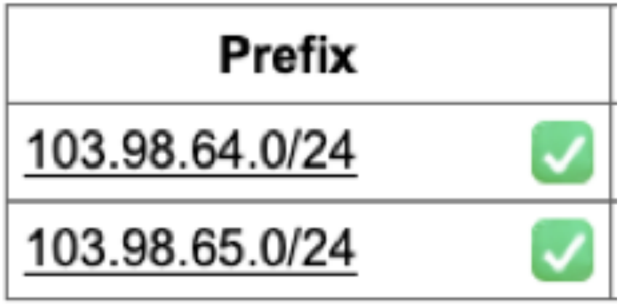


Prefix	
103.98.200.0/22	✓
103.98.200.0/24	✓
103.98.201.0/24	✓
103.98.202.0/24	✓
103.98.203.0/24	✓

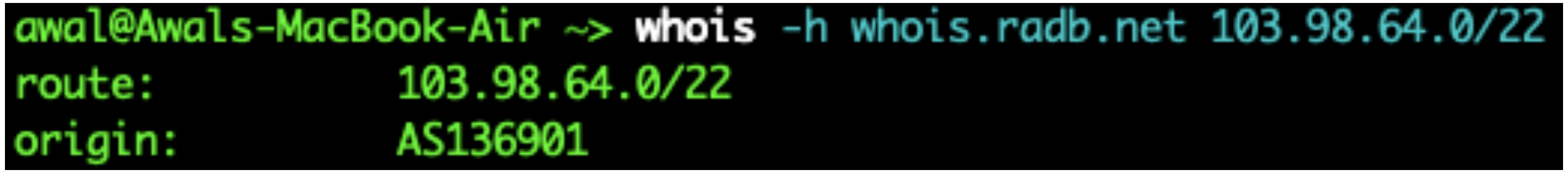


Prefix	
115.127.0.0/17	✓
115.127.0.0/18	✓
115.127.0.0/19	✓
115.127.0.0/20	✓
115.127.0.0/24	✓
115.127.1.0/24	✓
115.127.2.0/24	✓
115.127.3.0/24	✓
115.127.4.0/24	✓

- AS 136901 got an allocation of /22.
- They announce part of its prefix (not the whole), e.g. /23 is announced but the other /23 is not.
- Opportunists can try to use the unannounced /23 for unauthorized activities.

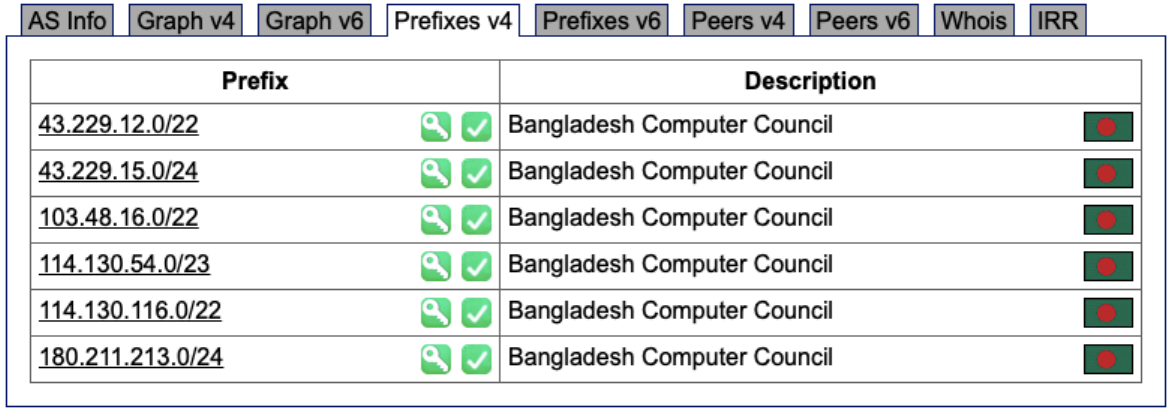


Prefix	
103.98.64.0/24	✓
103.98.65.0/24	✓

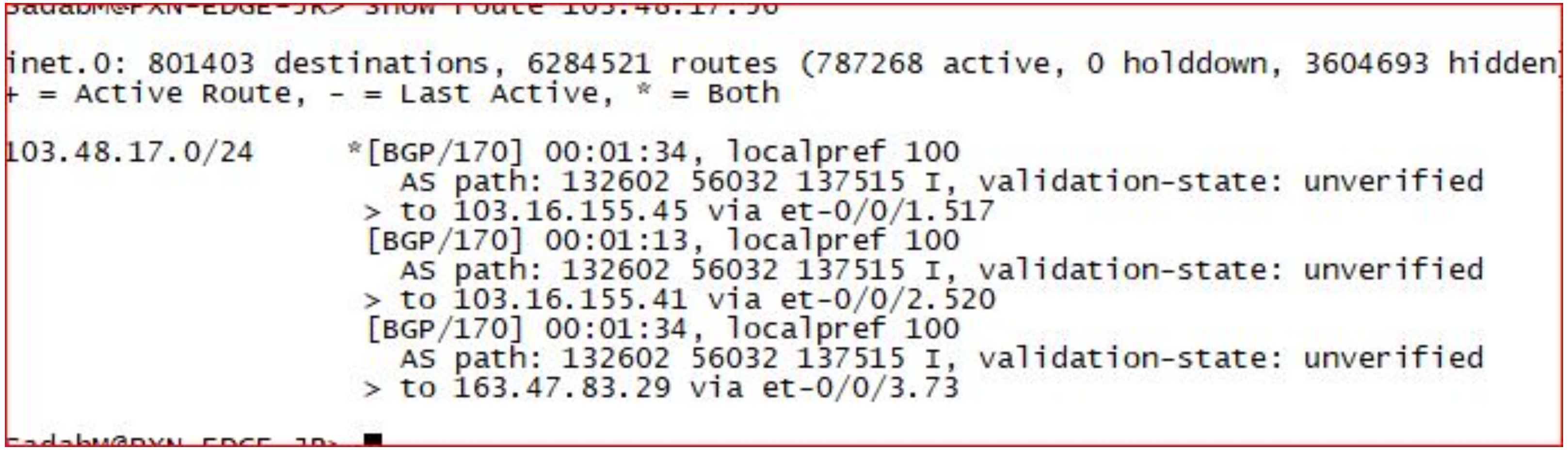


```
awal@Awals-MacBook-Air ~> whois -h whois.radb.net 103.98.64.0/22
route:          103.98.64.0/22
origin:         AS136901
```

- AS 137515 announced BCC's prefix 103.48.17.0/24 in a NIX (Prefix hijack)
- Important government services became unavailable to the citizens
- Cost our time to fix.



Prefix	Description
43.229.12.0/22 ✓	Bangladesh Computer Council
43.229.15.0/24 ✓	Bangladesh Computer Council
103.48.16.0/22 ✓	Bangladesh Computer Council
114.130.54.0/23 ✓	Bangladesh Computer Council
114.130.116.0/22 ✓	Bangladesh Computer Council
180.211.213.0/24 ✓	Bangladesh Computer Council



```
SadabM@PXN-EDGE-JR> show route 103.48.17.50

inet.0: 801403 destinations, 6284521 routes (787268 active, 0 holddown, 3604693 hidden)
+ = Active Route, - = Last Active, * = Both

103.48.17.0/24     *[BGP/170] 00:01:34, localpref 100
                      AS path: 132602 56032 137515 I, validation-state: unverified
                    > to 103.16.155.45 via et-0/0/1.517
                    [BGP/170] 00:01:13, localpref 100
                      AS path: 132602 56032 137515 I, validation-state: unverified
                    > to 103.16.155.41 via et-0/0/2.520
                    [BGP/170] 00:01:34, localpref 100
                      AS path: 132602 56032 137515 I, validation-state: unverified
                    > to 163.47.83.29 via et-0/0/3.73

SadabM@PXN-EDGE-JR>
```

What they reply about it? Funny but they really did

- We mistakenly announced the prefix
- We do not manually check our clients' APNIC membership status
- The client is very close to us and well trustworthy, so we never required to check their announcements
- We don't do prefix or AS filtering for our clients
- Forgot to stop announcing the prefix after it's delegated to another AS

Image source: Internet

How we ensure the routing hygiene manually?

Nightmare…

Image source: Internet

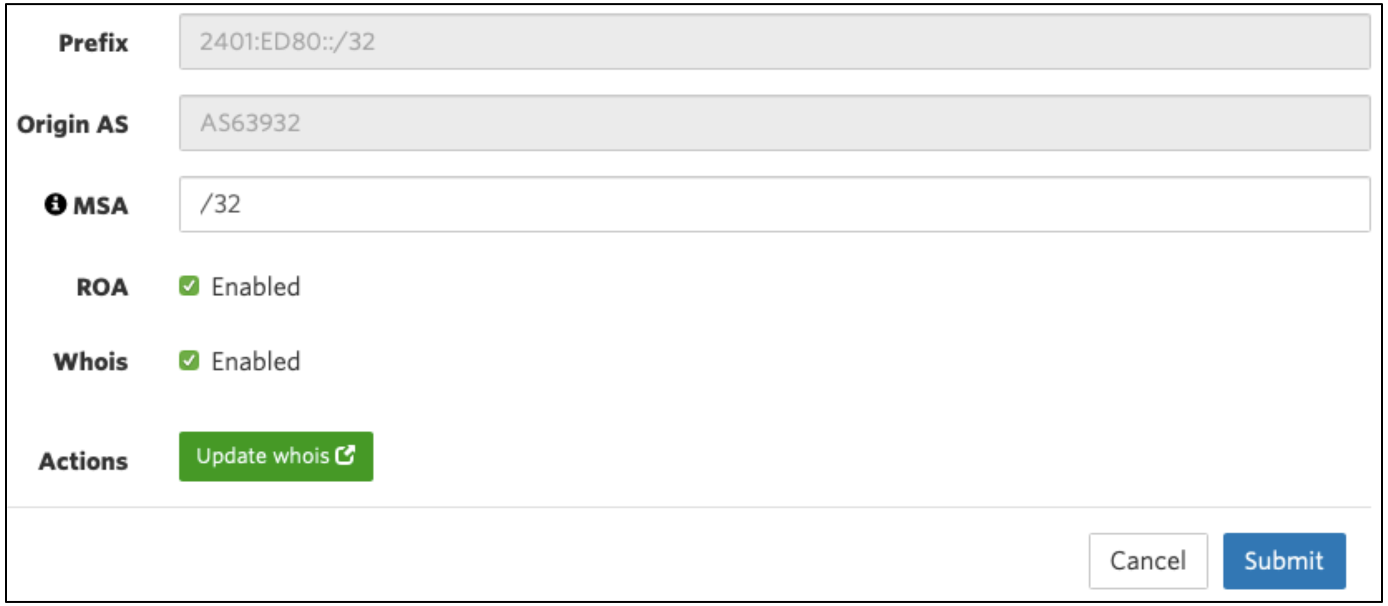
Image source: Internet

RPKI is about 2 things: ROA and ROV

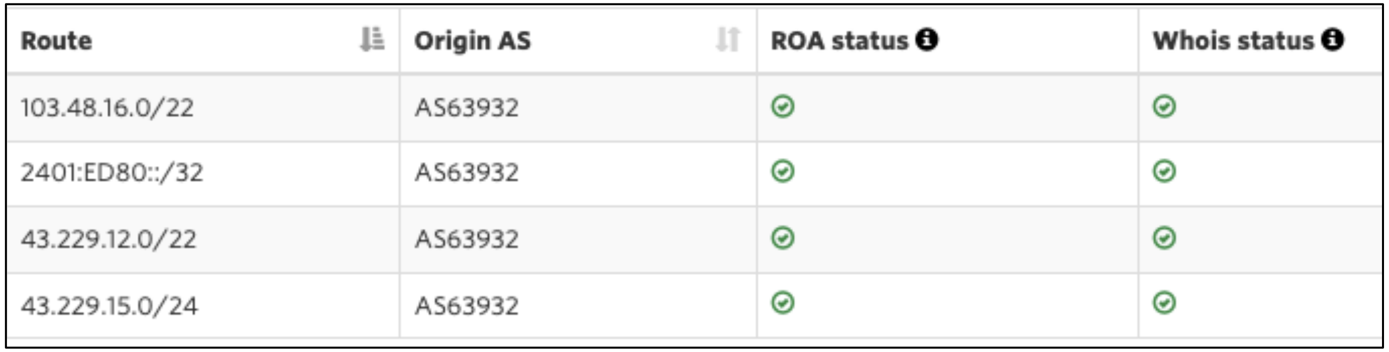
1

Signing prefixes

a.k.a. creating ROAs

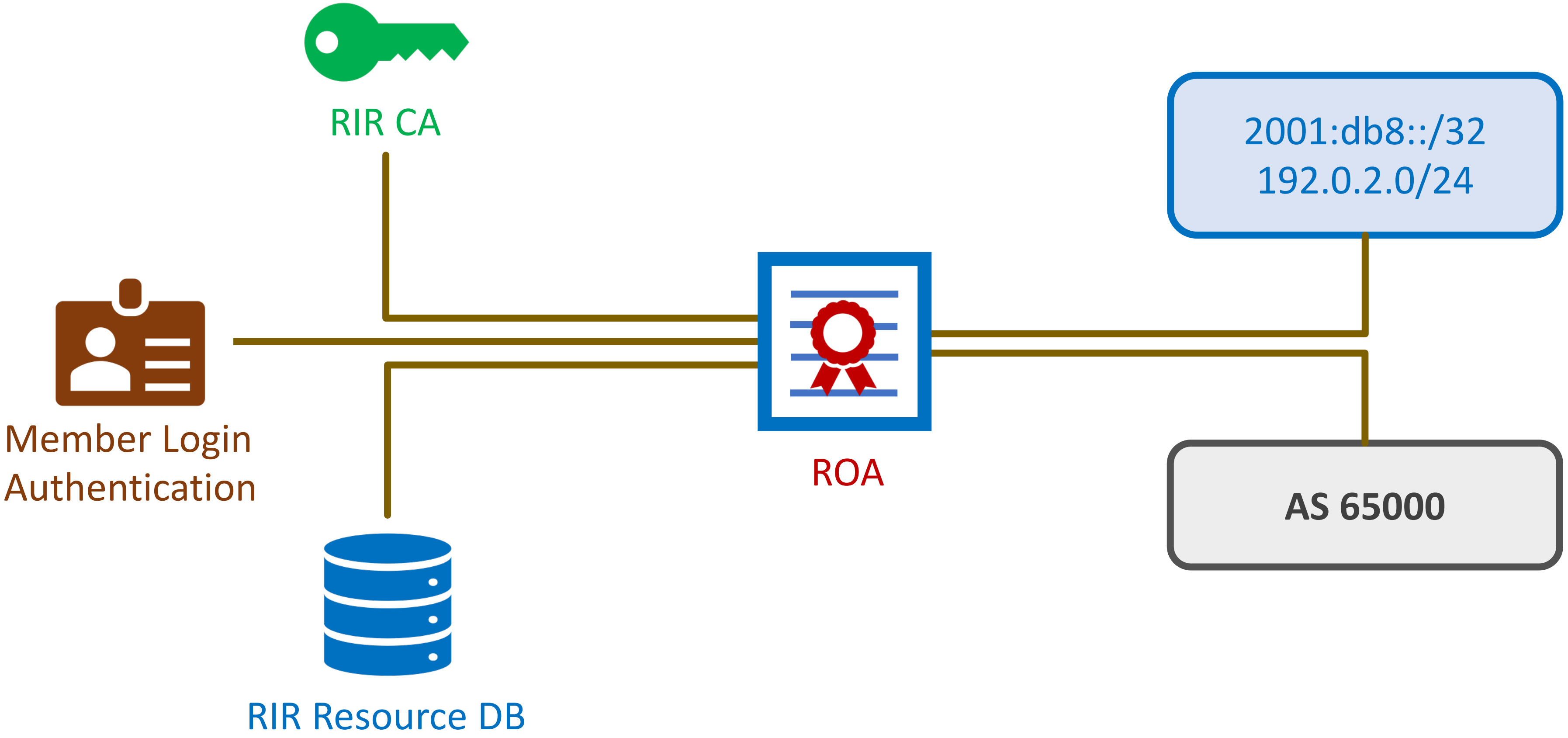


Prefix	2401:ED80::/32
Origin AS	AS63932
MSA	/32
ROA	☑ Enabled
Whois	☑ Enabled



Route	Origin AS	ROA status	Whois status
103.48.16.0/22	AS63932	✓	✓
2401:ED80::/32	AS63932	✓	✓
43.229.12.0/22	AS63932	✓	✓
43.229.15.0/24	AS63932	✓	✓

RPKI is about 2 things: ROA and ROV

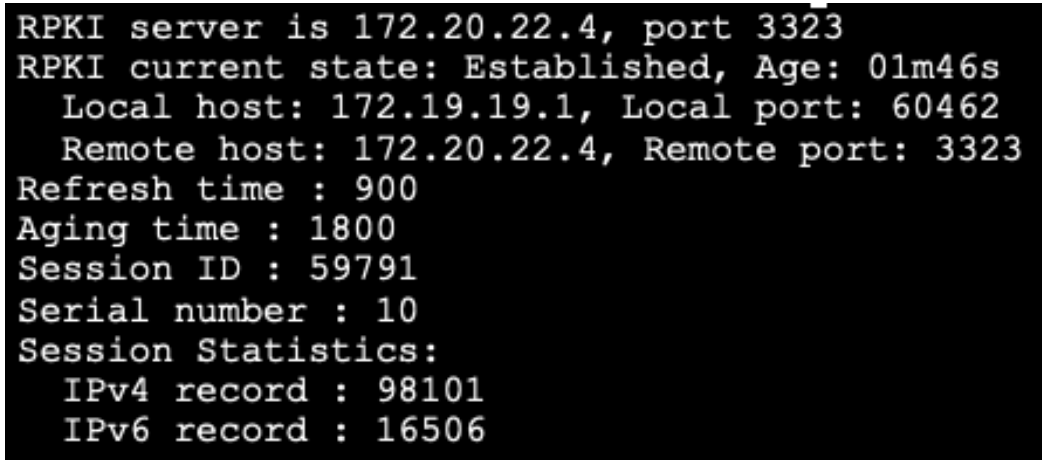


RPKI is about 2 things: ROA and ROV

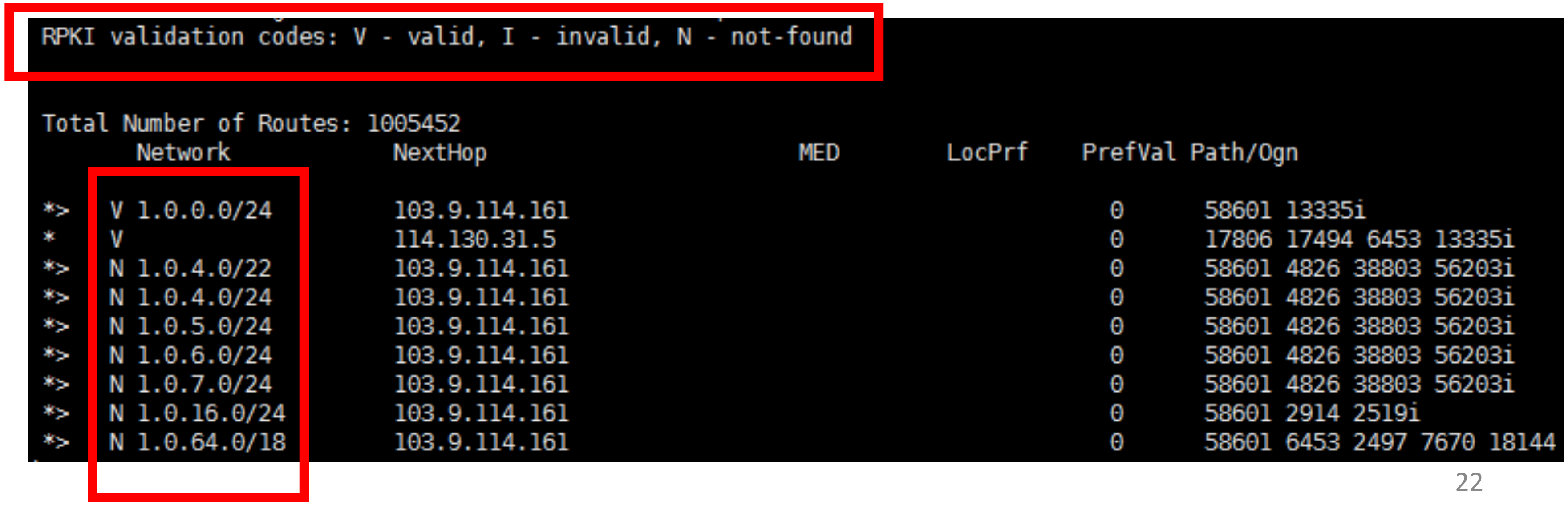
2

Validating ROAs

a.k.a Route Origin Validation

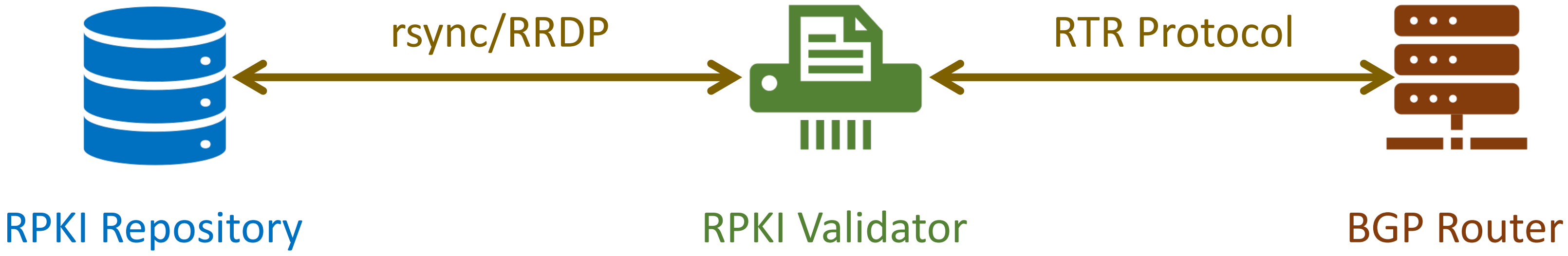


```
RPKI server is 172.20.22.4, port 3323
RPKI current state: Established, Age: 01m46s
  Local host: 172.19.19.1, Local port: 60462
  Remote host: 172.20.22.4, Remote port: 3323
Refresh time : 900
Aging time : 1800
Session ID : 59791
Serial number : 10
Session Statistics:
  IPv4 record : 98101
  IPv6 record : 16506
```

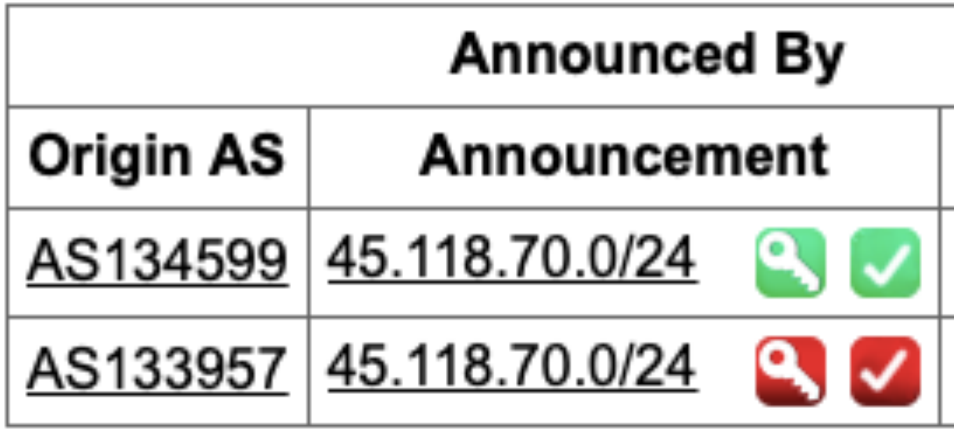


```
RPKI validation codes: V - valid, I - invalid, N - not-found

Total Number of Routes: 1005452
       Network            NextHop                        MED        LocPrf     PrefVal Path/Ogn

*>   V 1.0.0.0/24        103.9.114.161                                          0        58601 13335i
*    V                   114.130.31.5                                           0        17806 17494 6453 13335i
*>   N 1.0.4.0/22        103.9.114.161                                          0        58601 4826 38803 56203i
*>   N 1.0.4.0/24        103.9.114.161                                          0        58601 4826 38803 56203i
*>   N 1.0.5.0/24        103.9.114.161                                          0        58601 4826 38803 56203i
*>   N 1.0.6.0/24        103.9.114.161                                          0        58601 4826 38803 56203i
*>   N 1.0.7.0/24        103.9.114.161                                          0        58601 4826 38803 56203i
*>   N 1.0.16.0/24       103.9.114.161                                          0        58601 2914 2519i
*>   N 1.0.64.0/18       103.9.114.161                                          0        58601 6453 2497 7670 18144
```

RPKI is about 2 things: ROA and ROV



Why Create ROA?



	Announced By
Origin AS	Announcement
AS134599	45.118.70.0/24 🔑 ✓
AS133957	45.118.70.0/24 🔑 ✓

To ensure the authenticity of your IP resources and help others verify it if requires

So that your IP resources are not knowingly or unknowingly used or abused by anyone

Why Deploy ROV?

To build and maintain a secure and trustworthy global routing infrastructure

To validate BGP routes and identify the authorized originator of the prefix

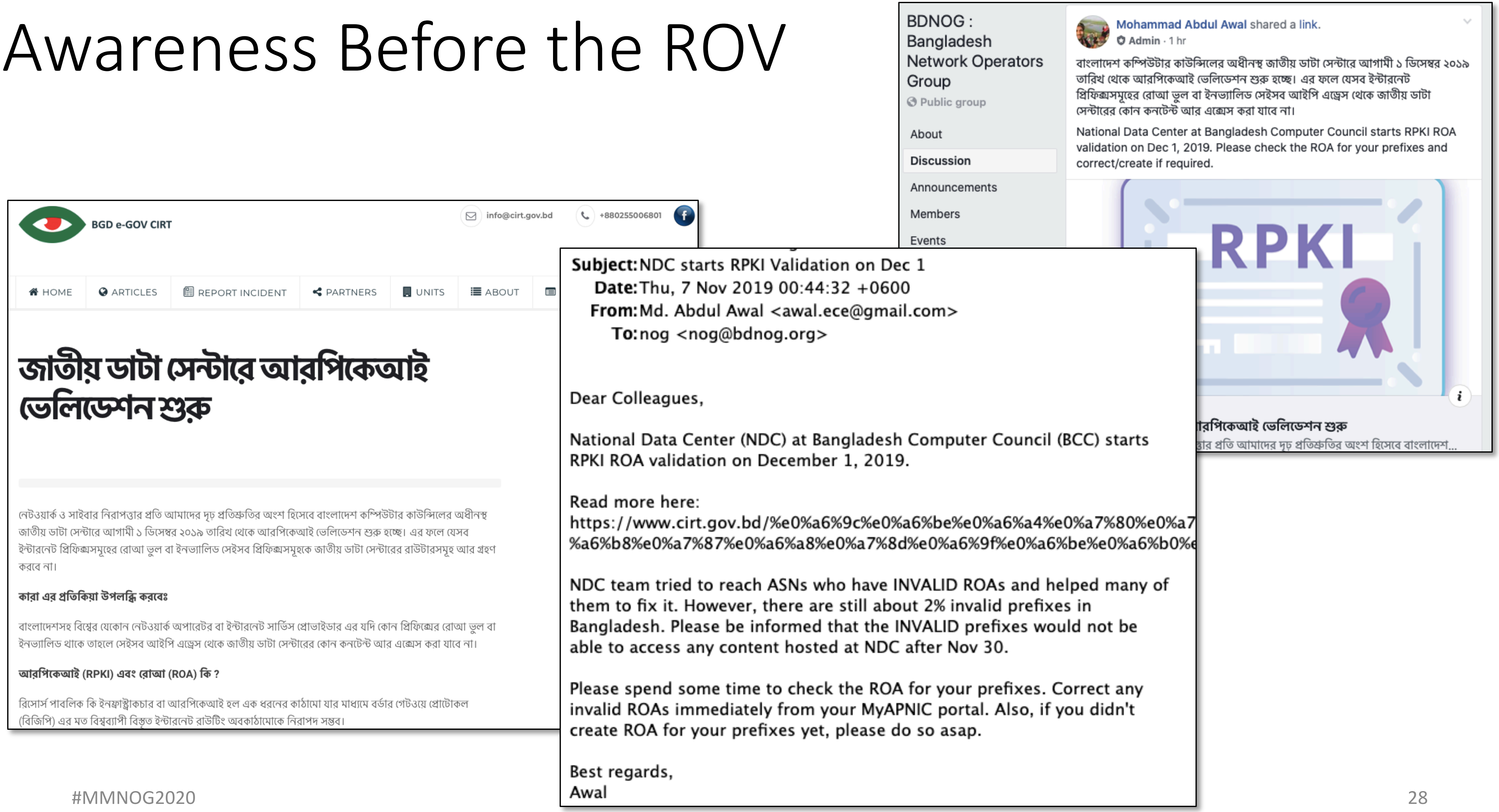
Image source: Internet

RPKI Validation in NDC and subsequent impact

RPKI Validation at National Data Center

- NDC declared to drop invalids since Dec 1, 2019
- Bangladesh has more than 700 active ASN
- BD ROA stats in Sep 2019:
  - Valid – 29%
  - Unknown – 69%
  - Invalid – 2%
- Need to find out ASNs who are getting impact
  - BD ASNs are easy to reach for obvious reason
  - How about the global ASNs?

Awareness Before the ROV



BDNOG : Bangladesh Network Operators Group

Public group

Mohammad Abdul Awal shared a link.

Admin · 1 hr

বাংলাদেশ কম্পিউটার কাউন্সিলের অধীনস্থ জাতীয় ডাটা সেন্টারে আগামী ১ ডিসেম্বর ২০১৯ তারিখ থেকে আরপিকেআই ভেলিডেশন শুরু হচ্ছে। এর ফলে যেসব ইন্টারনেট প্রিফিক্সসমূহের রোআ ভুল বা ইনভ্যালিড সেইসব আইপি এড্রেস থেকে জাতীয় ডাটা সেন্টারের কোন কনটেন্ট আর এক্সেস করা যাবে না।

National Data Center at Bangladesh Computer Council starts RPKI ROA validation on Dec 1, 2019. Please check the ROA for your prefixes and correct/create if required.

ারপিকেআই ভেলিডেশন শুরু

ত্তার প্রতি আমাদের দৃঢ় প্রতিশ্রুতির অংশ হিসেবে বাংলাদেশ...

BGD e-GOV CIRT

info@cirt.gov.bd

+880255006801

জাতীয় ডাটা সেন্টারে আরপিকেআই ভেলিডেশন শুরু

নেটওয়ার্ক ও সাইবার নিরাপত্তার প্রতি আমাদের দৃঢ় প্রতিশ্রুতির অংশ হিসেবে বাংলাদেশ কম্পিউটার কাউন্সিলের অধীনস্থ জাতীয় ডাটা সেন্টারে আগামী ১ ডিসেম্বর ২০১৯ তারিখ থেকে আরপিকেআই ভেলিডেশন শুরু হচ্ছে। এর ফলে যেসব ইন্টারনেট প্রিফিক্সসমূহের রোআ ভুল বা ইনভ্যালিড সেইসব প্রিফিক্সসমূহকে জাতীয় ডাটা সেন্টারের রাউটারসমূহ আর গ্রহণ করবে না।

কারা এর প্রতিকিয়া উপলব্ধি করবেঃ

বাংলাদেশসহ বিশ্বের যেকোন নেটওয়ার্ক অপারেটর বা ইন্টারনেট সার্ভিস প্রোভাইডার এর যদি কোন প্রিফিক্সের রোআ ভুল বা ইনভ্যালিড থাকে তাহলে সেইসব আইপি এড্রেস থেকে জাতীয় ডাটা সেন্টারের কোন কনটেন্ট আর এক্সেস করা যাবে না।

আরপিকেআই (RPKI) এবং রোআ (ROA) কি ?

রিসোর্স পাবলিক কি ইনফ্রাস্ট্রাকচার বা আরপিকেআই হল এক ধরনের কাঠামো যার মাধ্যমে বর্ডার গেটওয়ে প্রোটোকল (বিজিপি) এর মত বিশ্বব্যাপী বিস্তৃত ইন্টারনেট রাউটিং অবকাঠামোকে নিরাপদ সম্ভব।

Subject: NDC starts RPKI Validation on Dec 1
Date: Thu, 7 Nov 2019 00:44:32 +0600
From: Md. Abdul Awal <awal.ece@gmail.com>
To: nog <nog@bdnog.org>

Dear Colleagues,

National Data Center (NDC) at Bangladesh Computer Council (BCC) starts RPKI ROA validation on December 1, 2019.

Read more here:
https://www.cirt.gov.bd/%e0%a6%9c%e0%a6%be%e0%a6%a4%e0%a7%80%e0%a7
%a6%b8%e0%a7%87%e0%a6%a8%e0%a7%8d%e0%a6%9f%e0%a6%be%e0%a6%b0%e

NDC team tried to reach ASNs who have INVALID ROAs and helped many of them to fix it. However, there are still about 2% invalid prefixes in Bangladesh. Please be informed that the INVALID prefixes would not be able to access any content hosted at NDC after Nov 30.

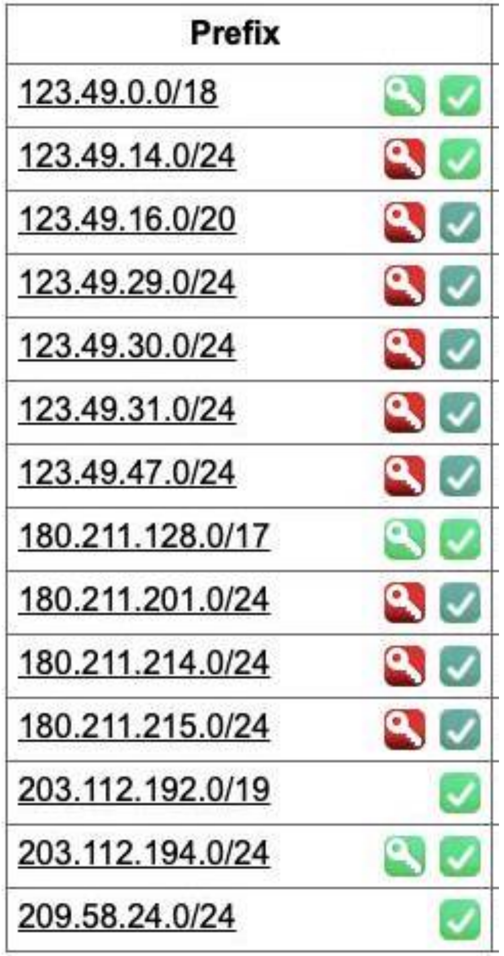
Please spend some time to check the ROA for your prefixes. Correct any invalid ROAs immediately from your MyAPNIC portal. Also, if you didn't create ROA for your prefixes yet, please do so asap.

Best regards,
Awal

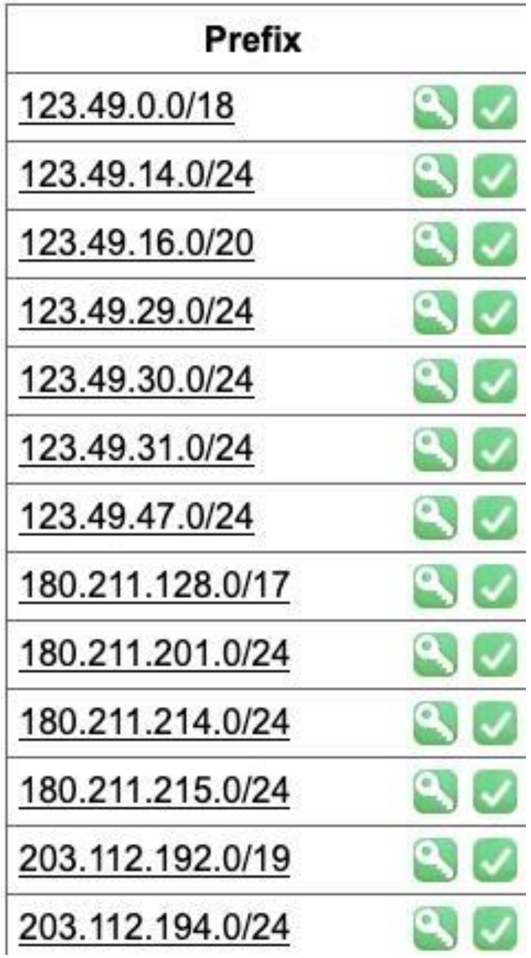
Awareness Before the ROV

- We helped others to create and/or fix their ROAs
  - LEAs, Police, Special forces
  - Govt. Organizations
  - IXPs
  - Banks and Financial Organizations
  - Transit providers
  - ISPs
  - Data Centers

The impact of awareness campaign



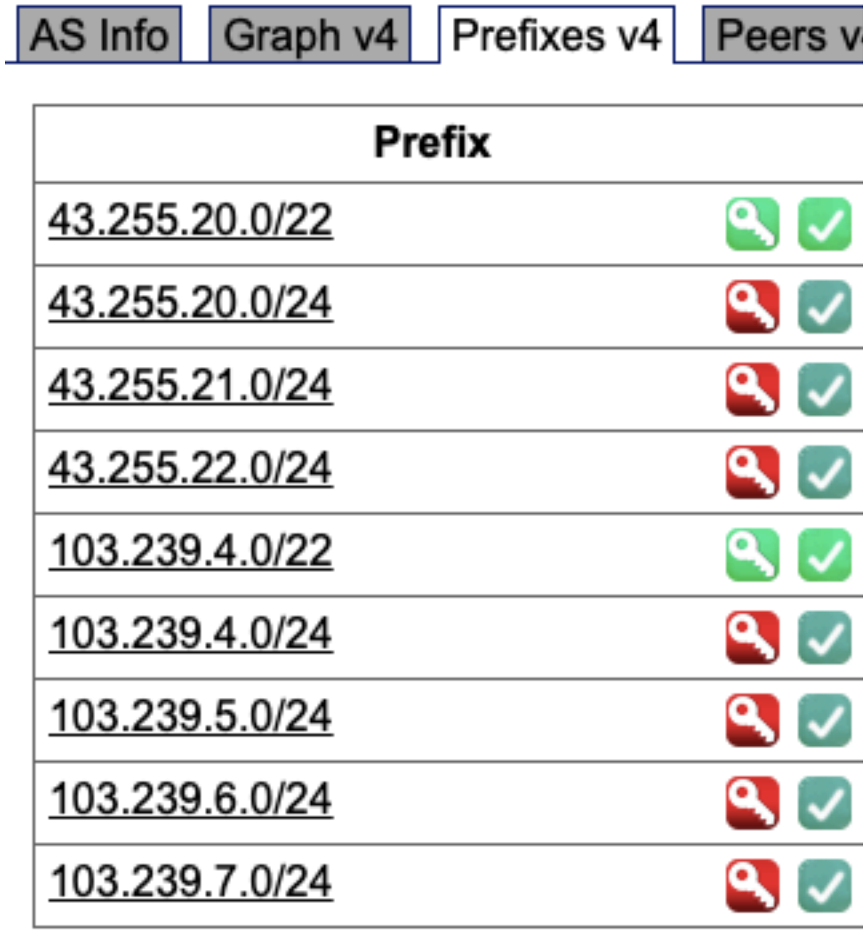
Prefix		
123.49.0.0/18	🟩	✓
123.49.14.0/24	🟥	✓
123.49.16.0/20	🟥	✓
123.49.29.0/24	🟥	✓
123.49.30.0/24	🟥	✓
123.49.31.0/24	🟥	✓
123.49.47.0/24	🟥	✓
180.211.128.0/17	🟩	✓
180.211.201.0/24	🟥	✓
180.211.214.0/24	🟥	✓
180.211.215.0/24	🟥	✓
203.112.192.0/19		✓
203.112.194.0/24	🟩	✓
209.58.24.0/24		✓



Prefix		
123.49.0.0/18	🟩	✓
123.49.14.0/24	🟩	✓
123.49.16.0/20	🟩	✓
123.49.29.0/24	🟩	✓
123.49.30.0/24	🟩	✓
123.49.31.0/24	🟩	✓
123.49.47.0/24	🟩	✓
180.211.128.0/17	🟩	✓
180.211.201.0/24	🟩	✓
180.211.214.0/24	🟩	✓
180.211.215.0/24	🟩	✓
203.112.192.0/19	🟩	✓
203.112.194.0/24	🟩	✓

Source: https://bgp.he.net

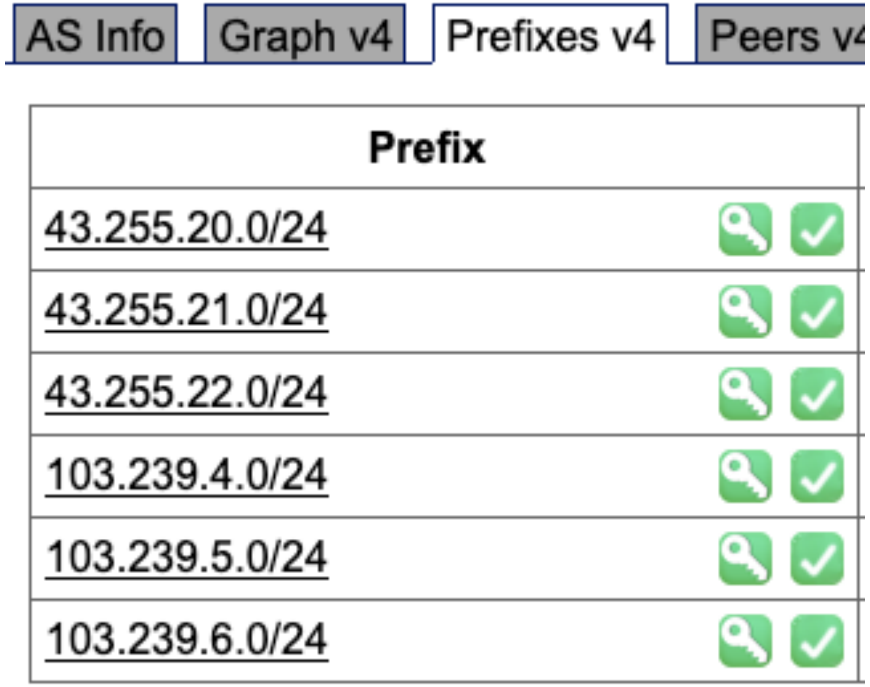
The impact of awareness campaign



AS Info | Graph v4 | Prefixes v4 | Peers v

Prefix	
43.255.20.0/22	🟩 ✓
43.255.20.0/24	🟥 ✓
43.255.21.0/24	🟥 ✓
43.255.22.0/24	🟥 ✓
103.239.4.0/22	🟩 ✓
103.239.4.0/24	🟥 ✓
103.239.5.0/24	🟥 ✓
103.239.6.0/24	🟥 ✓
103.239.7.0/24	🟥 ✓

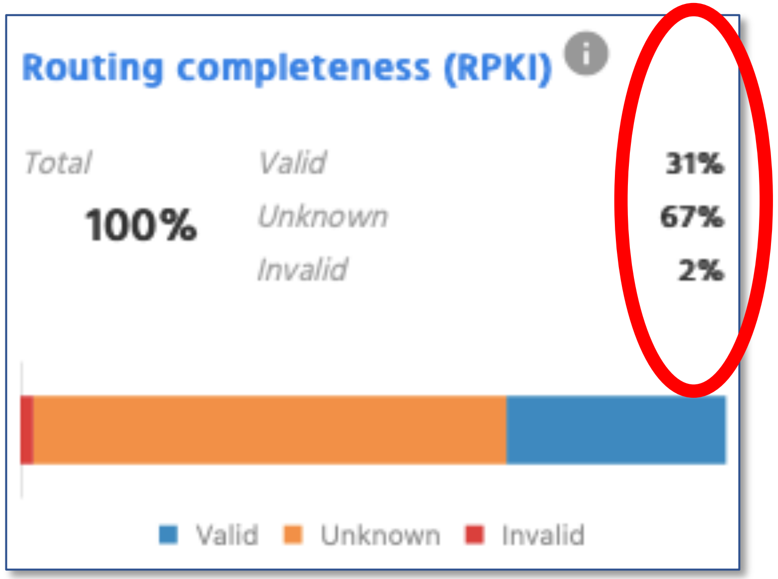
»



AS Info | Graph v4 | Prefixes v4 | Peers v4

Prefix	
43.255.20.0/24	🟩 ✓
43.255.21.0/24	🟩 ✓
43.255.22.0/24	🟩 ✓
103.239.4.0/24	🟩 ✓
103.239.5.0/24	🟩 ✓
103.239.6.0/24	🟩 ✓

The impact of awareness campaign

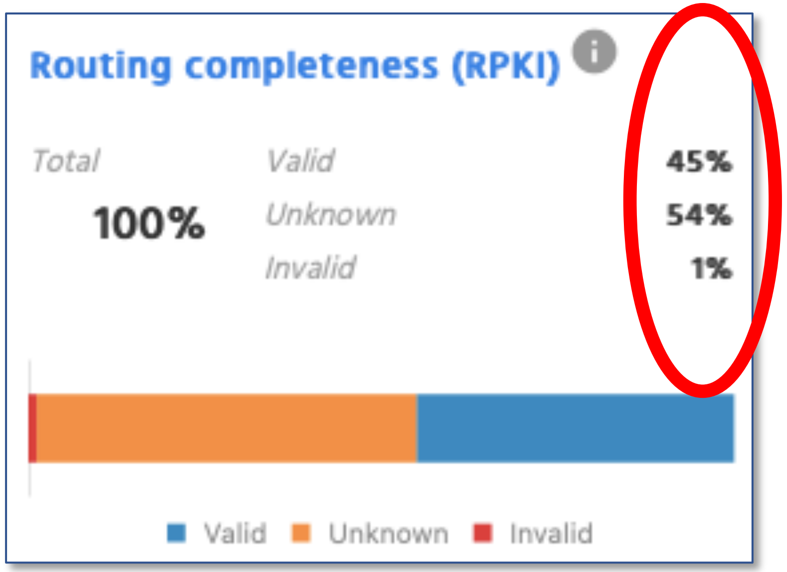


Routing completeness (RPKI)

Total		
100%	Valid	31%
	Unknown	67%
	Invalid	2%

🟦 Valid 🟧 Unknown 🟥 Invalid

Oct 2019

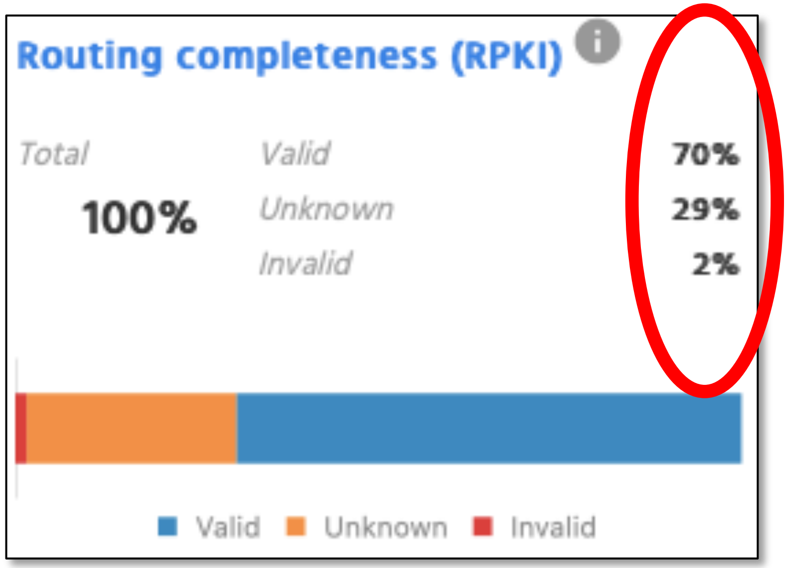


Routing completeness (RPKI)

Total		
100%	Valid	45%
	Unknown	54%
	Invalid	1%

🟦 Valid 🟧 Unknown 🟥 Invalid

Nov 2019



Routing completeness (RPKI)

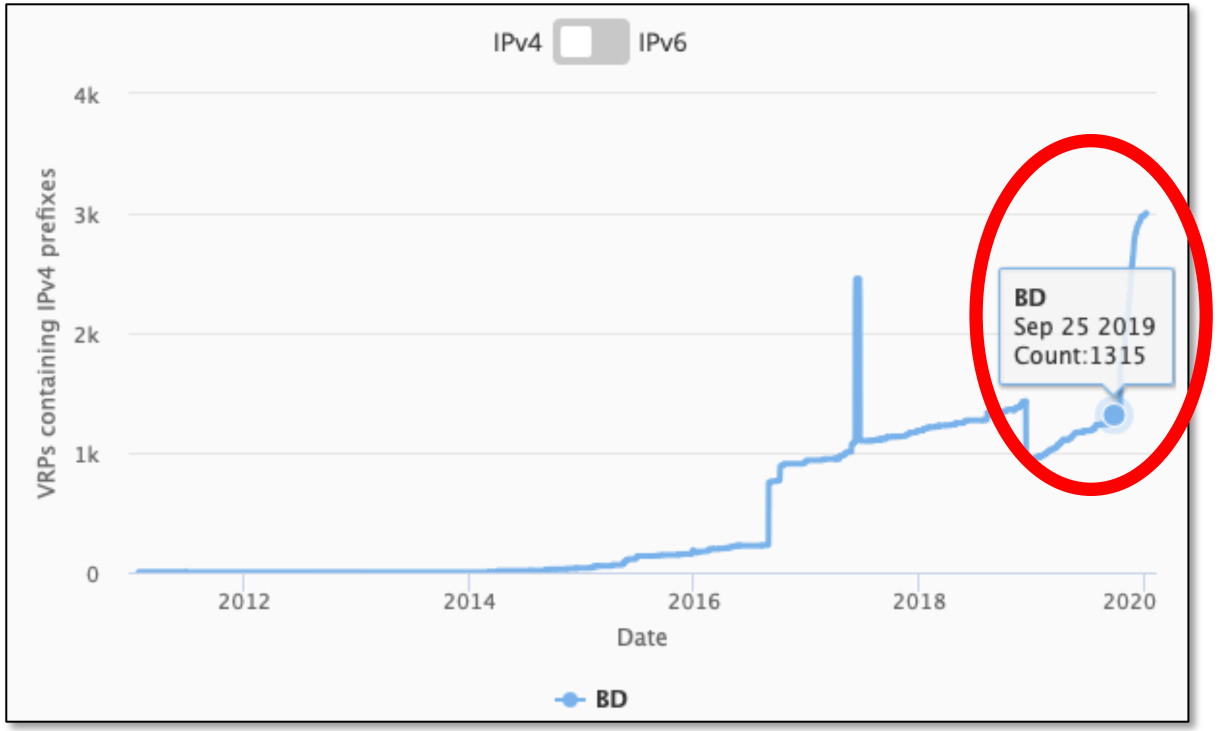
Total		
100%	Valid	70%
	Unknown	29%
	Invalid	2%

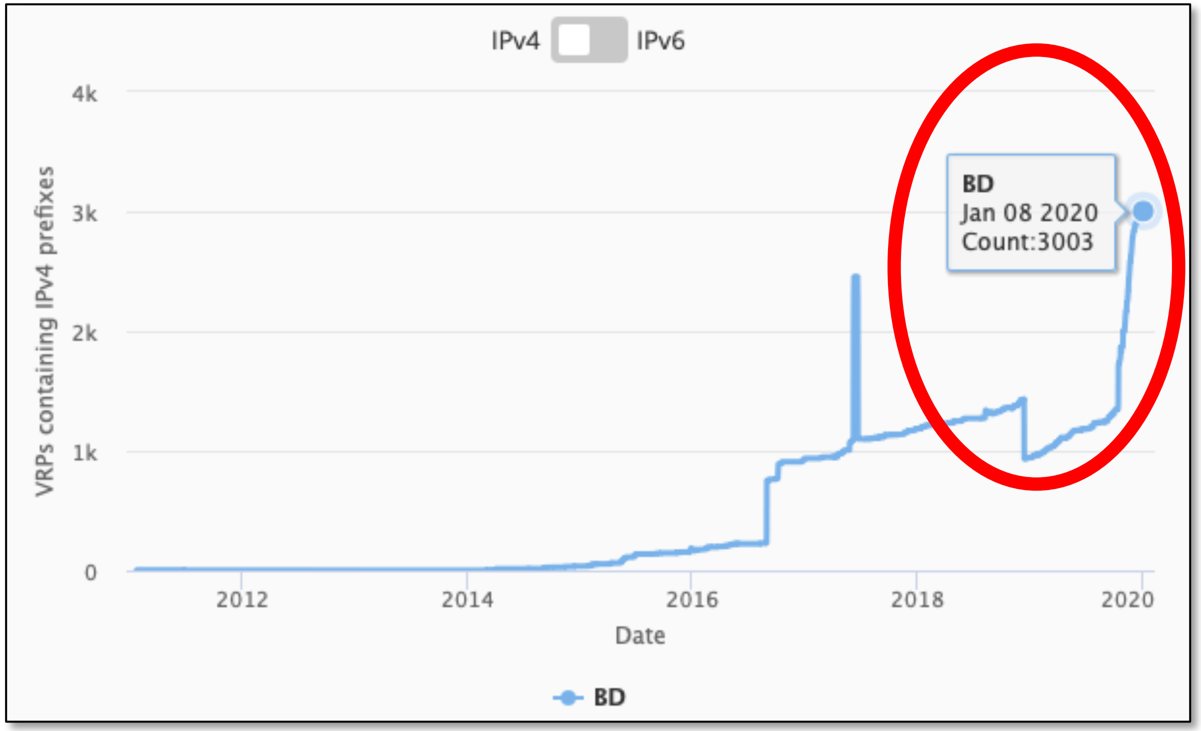
🟦 Valid 🟧 Unknown 🟥 Invalid

Dec 2019

Source: https://observatory.manrs.org

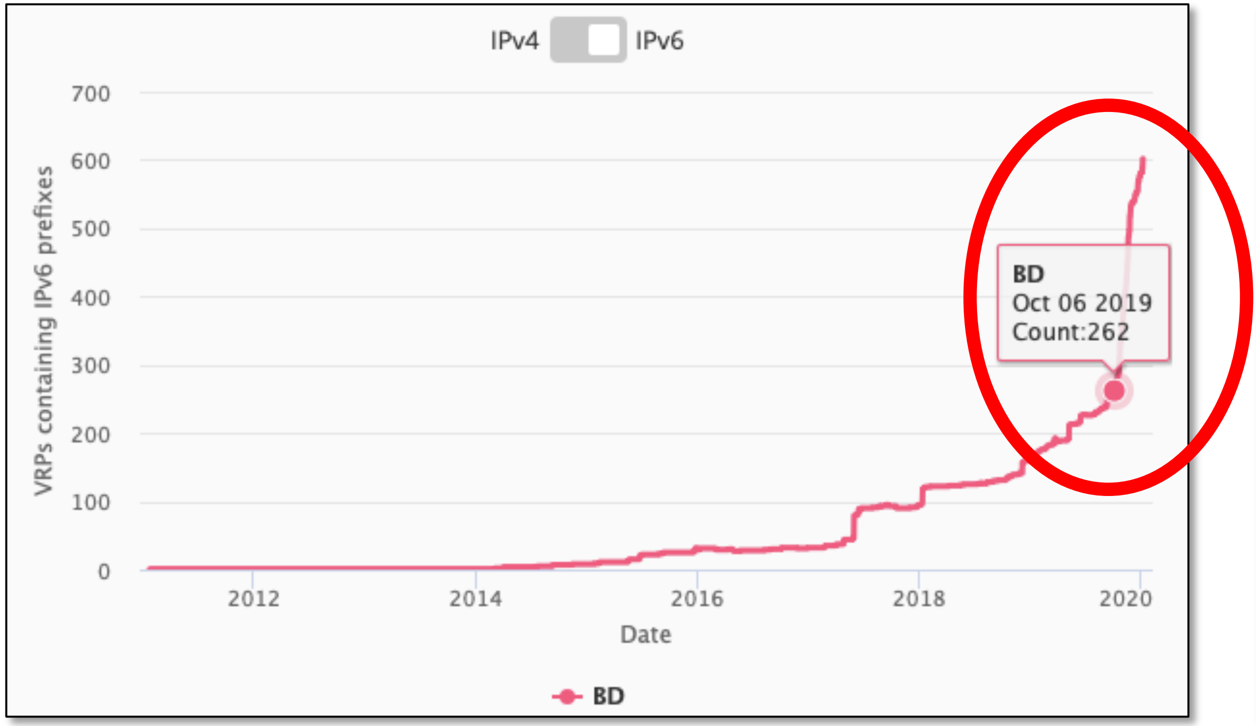
The impact of awareness campaign

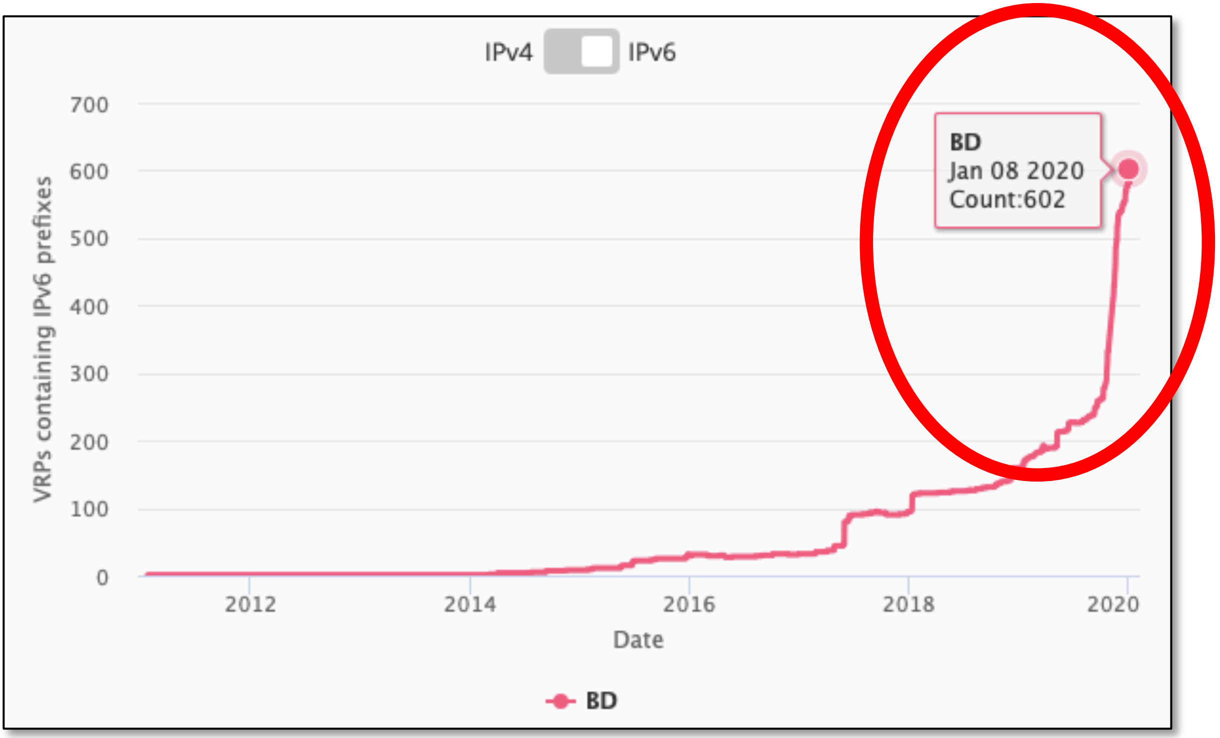




Source: https://stat.ripe.net/BD#tabId=routing

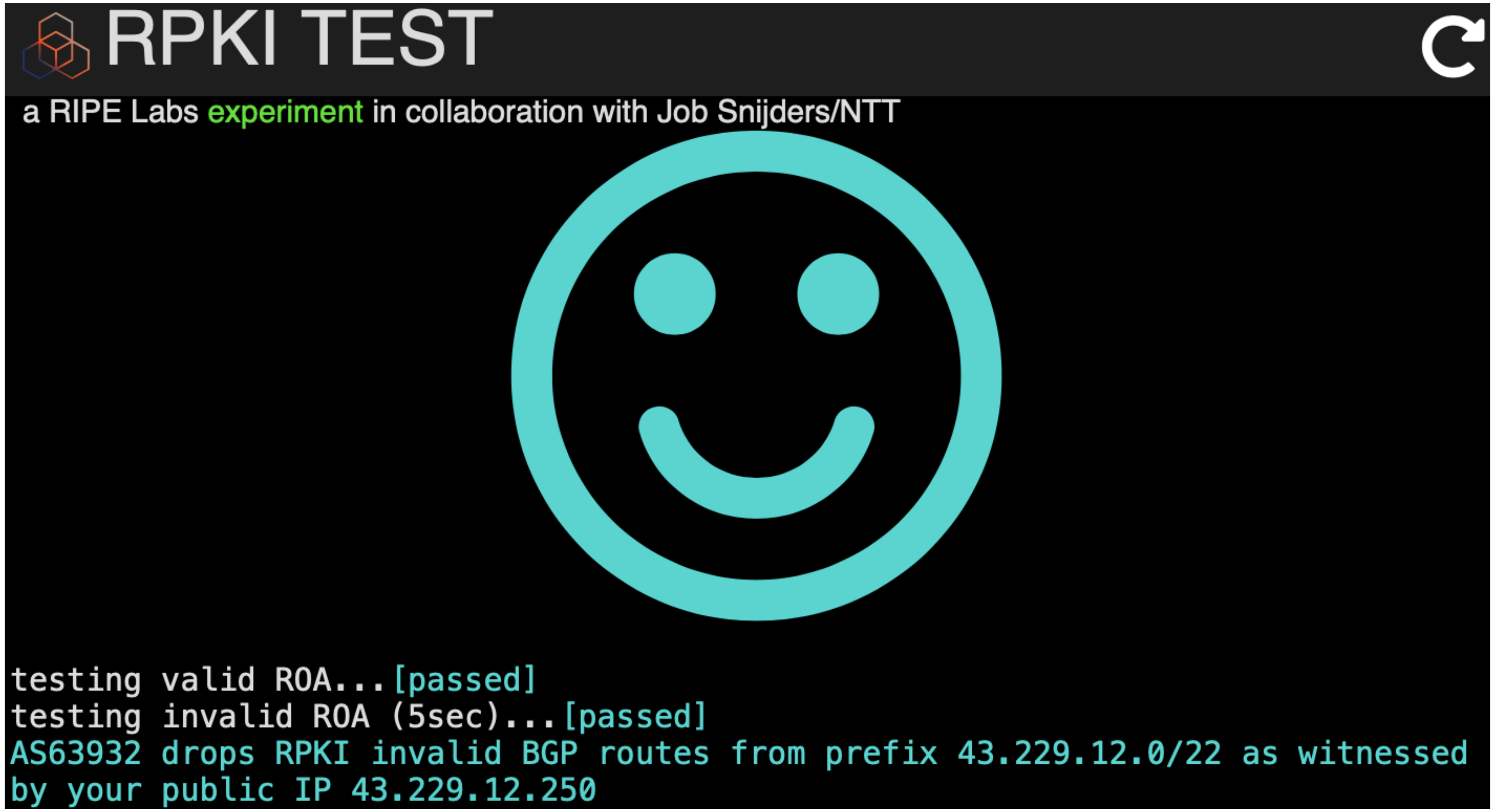
The impact of awareness campaign





Source: https://stat.ripe.net/BD#tabId=routing

And, finally NDC drops invalids since Dec 1, 2020



a RIPE Labs experiment in collaboration with Job Snijders/NTT

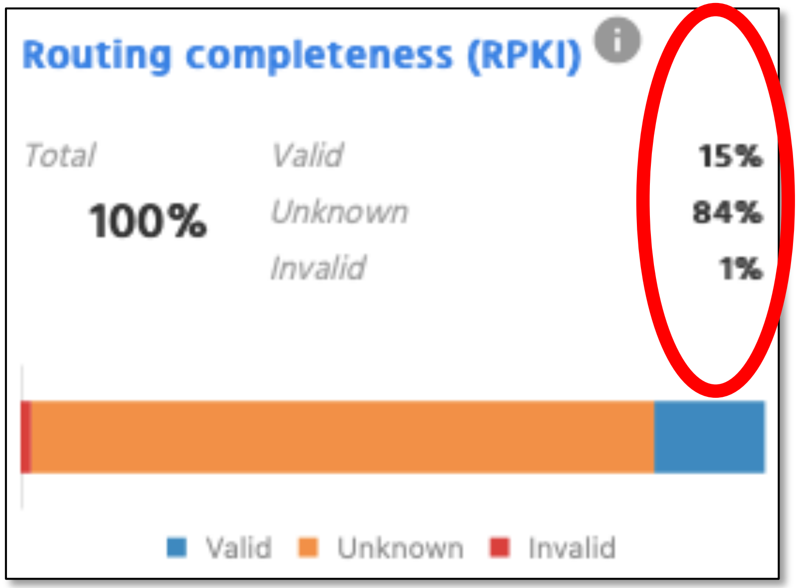
```
testing valid ROA...[passed]
testing invalid ROA (5sec)...[passed]
AS63932 drops RPKI invalid BGP routes from prefix 43.229.12.0/22 as witnessed
by your public IP 43.229.12.250
```

More organizations to start ROV

- BdREN (AS 63961) - Jan, 2020
- Summit Communications (AS 58717) – Jan 2019
- BD Link (AS 58668) – Jan, 2020
- Link3 Technologies (AS 23688) - TBD
- Cybergate (AS 58599) - TBD

How about South Asia and Myanmar?

RPKI Status in South Asia

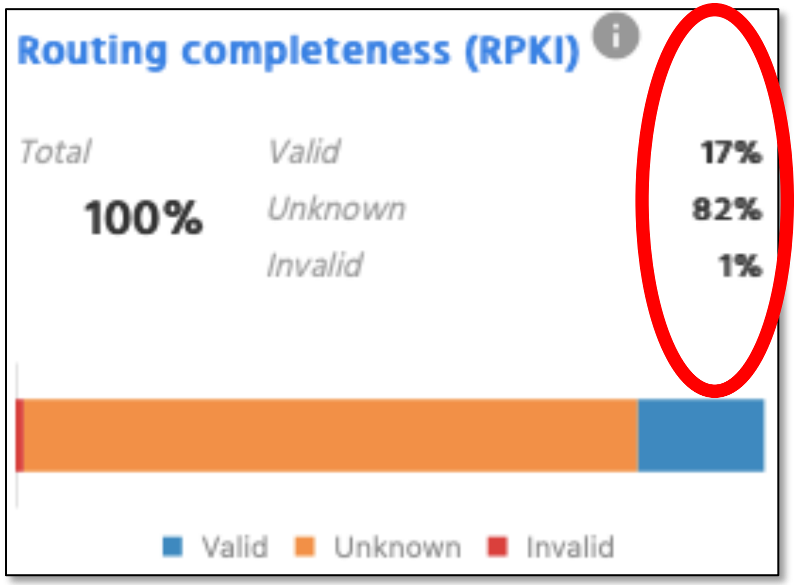


Routing completeness (RPKI)

Total		
100%	Valid	15%
	Unknown	84%
	Invalid	1%

🟦 Valid 🟧 Unknown 🟥 Invalid

Oct 2019

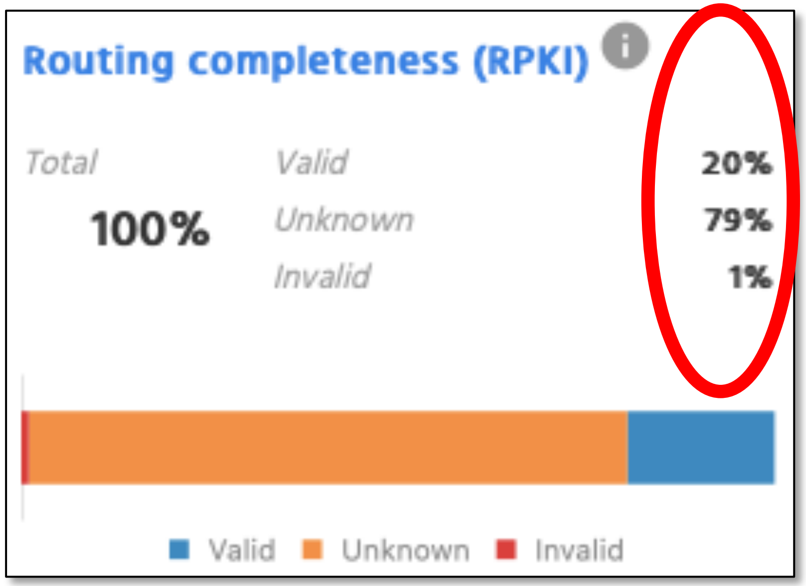


Routing completeness (RPKI)

Total		
100%	Valid	17%
	Unknown	82%
	Invalid	1%

🟦 Valid 🟧 Unknown 🟥 Invalid

Nov 2019



Routing completeness (RPKI)

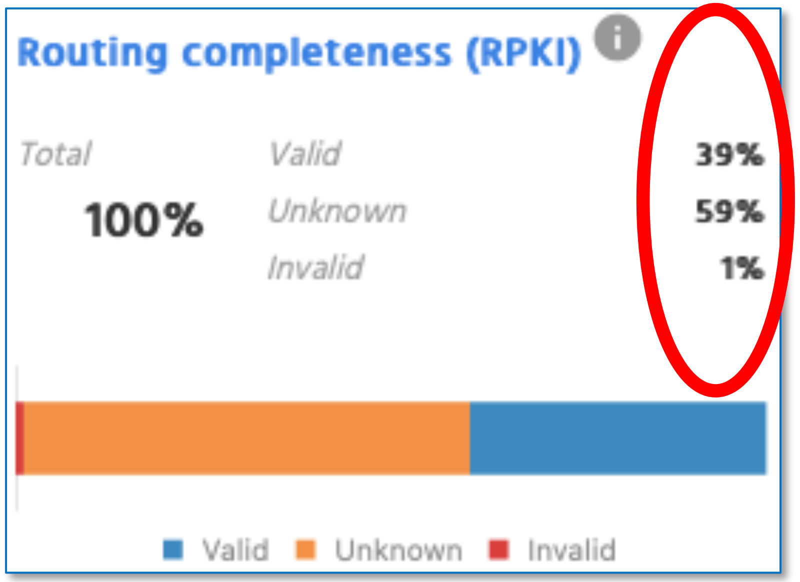
Total		
100%	Valid	20%
	Unknown	79%
	Invalid	1%

🟦 Valid 🟧 Unknown 🟥 Invalid

Dec 2019

Source: https://observatory.manrs.org

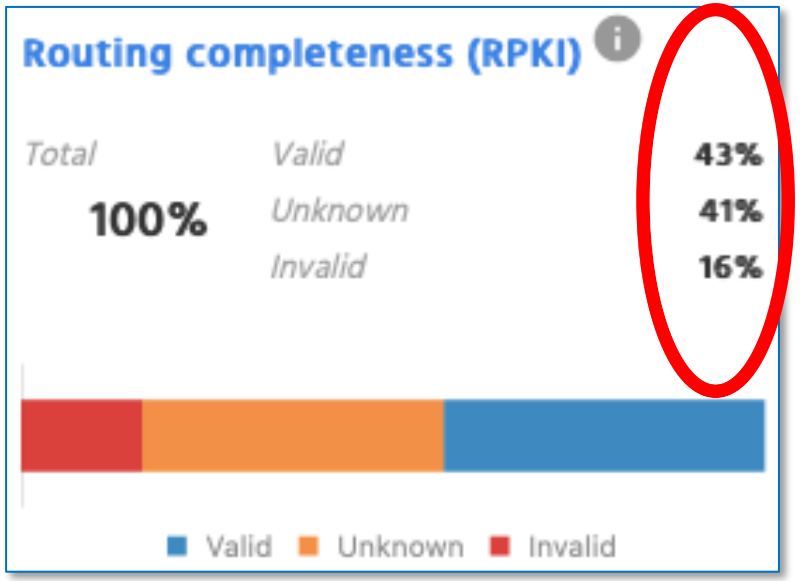
RPKI Status in Myanmar



Routing completeness (RPKI)

Total		
100%	Valid	39%
	Unknown	59%
	Invalid	1%

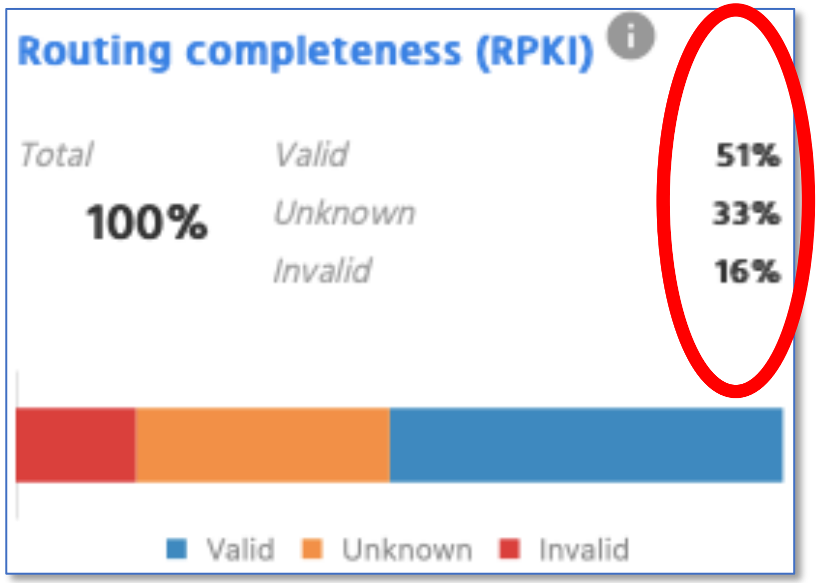
Oct 2019



Routing completeness (RPKI)

Total		
100%	Valid	43%
	Unknown	41%
	Invalid	16%

Nov 2019



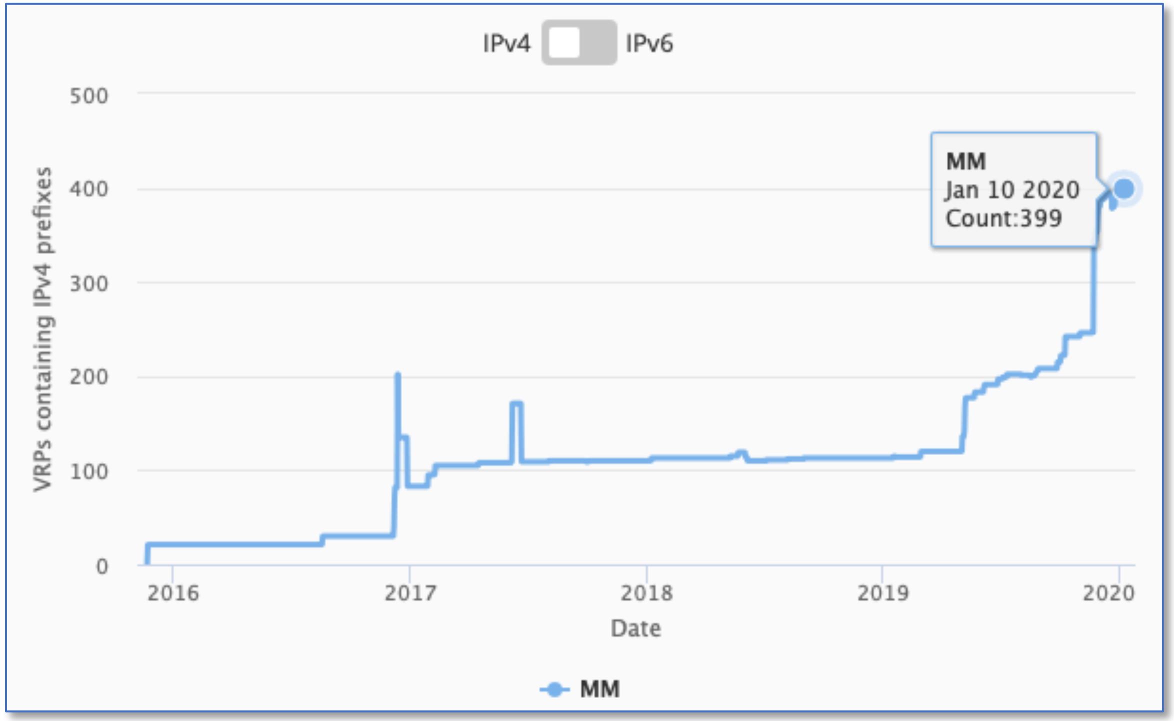
Routing completeness (RPKI)

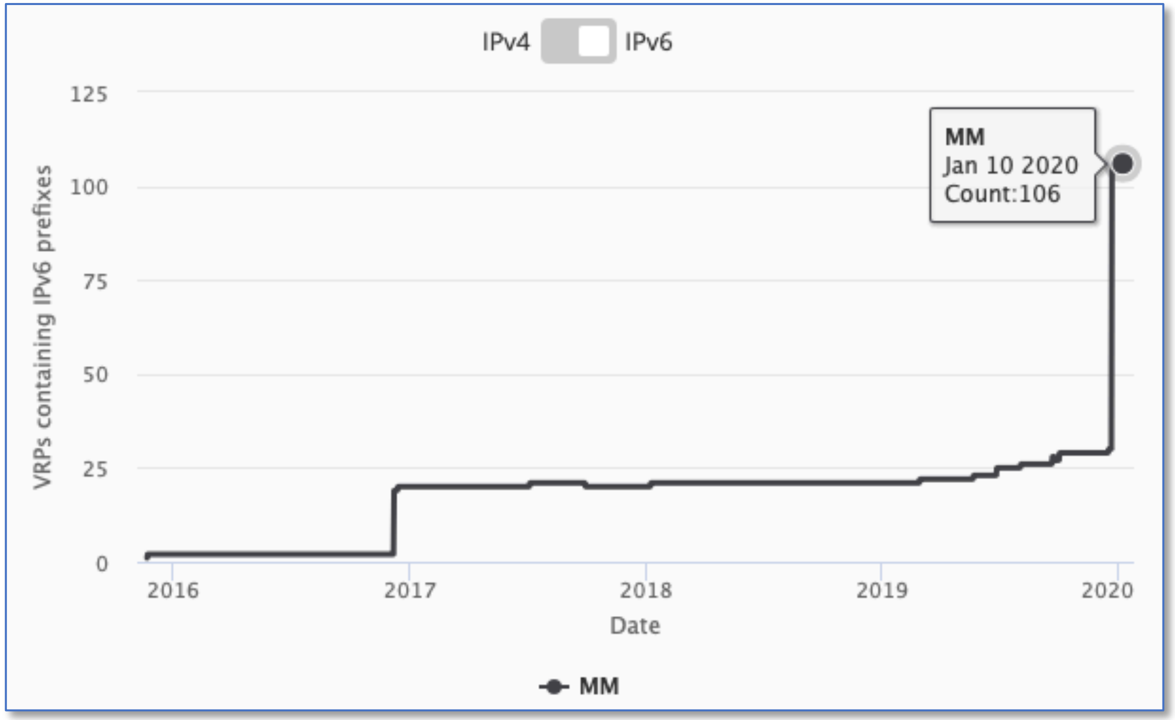
Total		
100%	Valid	51%
	Unknown	33%
	Invalid	16%

Dec 2019

Source: https://observatory.manrs.org

RPKI Status in Myanmar





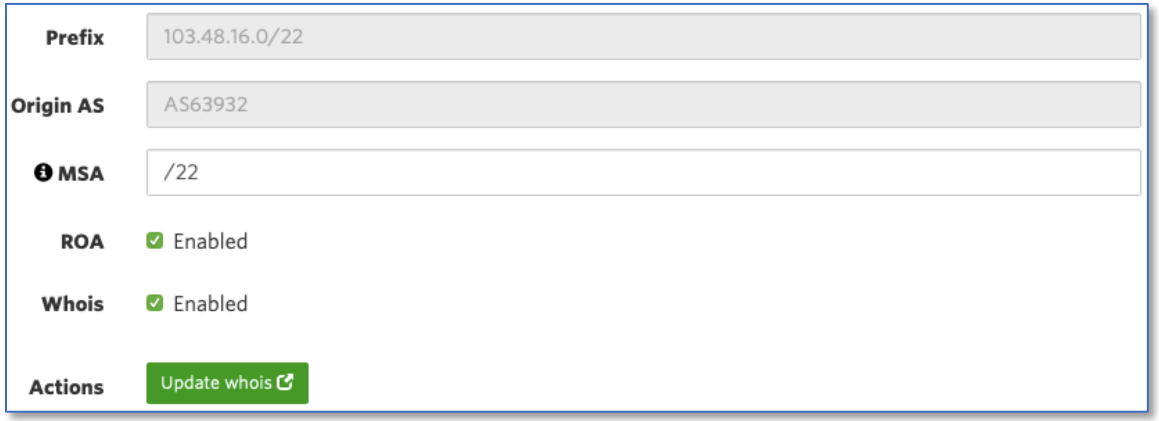
Source: https://ripe.net/analyse/statistics/ripestat

- Myanmar has about 16 % INVALID ROAs
  - We need to eliminate it completely
- Also, need to reduce UNKNOWNs
  - Sign the unsigned

And, think about doing
Route Origin Validation (ROV)

Considerations about ROA and ROV

Creating ROA



Prefix 103.48.16.0/22

Origin AS AS63932

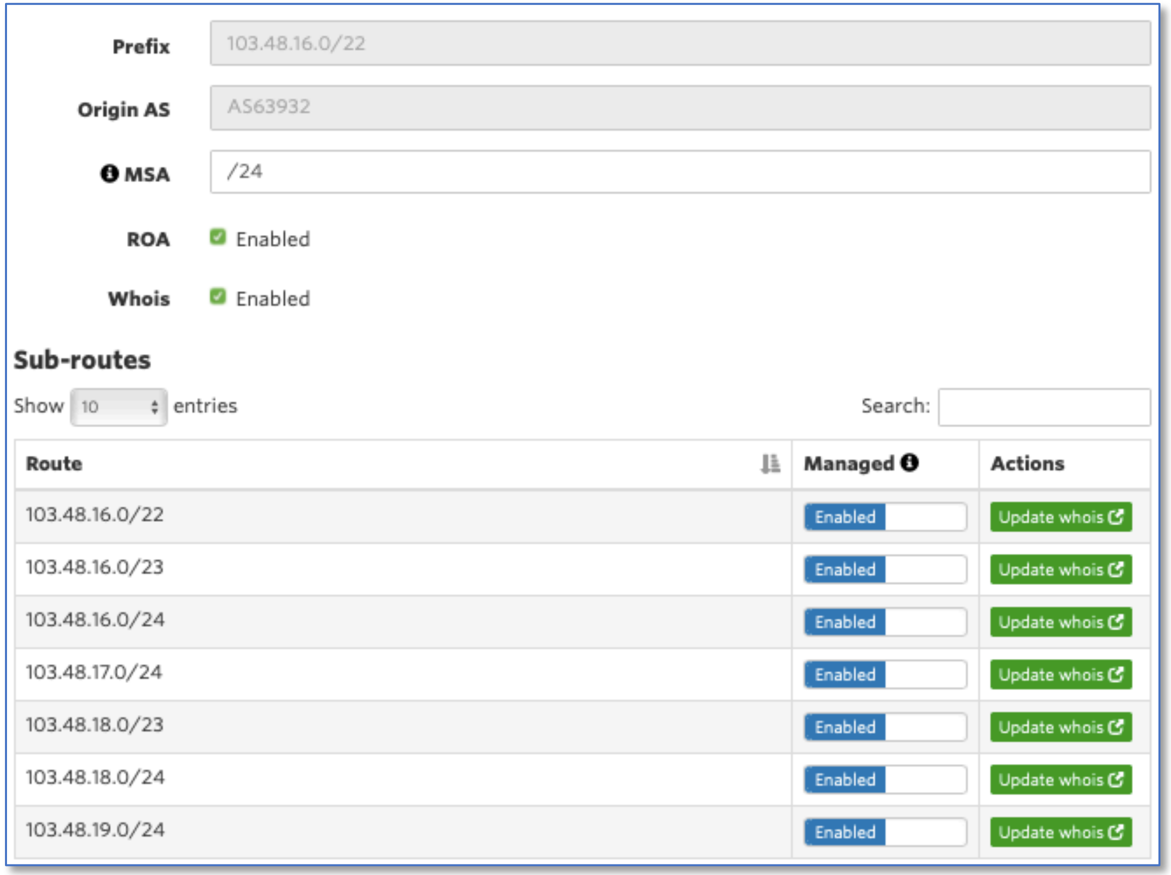
MSA /22

ROA ☑ Enabled

Whois ☑ Enabled

Actions Update whois

VS



Prefix 103.48.16.0/22

Origin AS AS63932

MSA /24

ROA ☑ Enabled

Whois ☑ Enabled

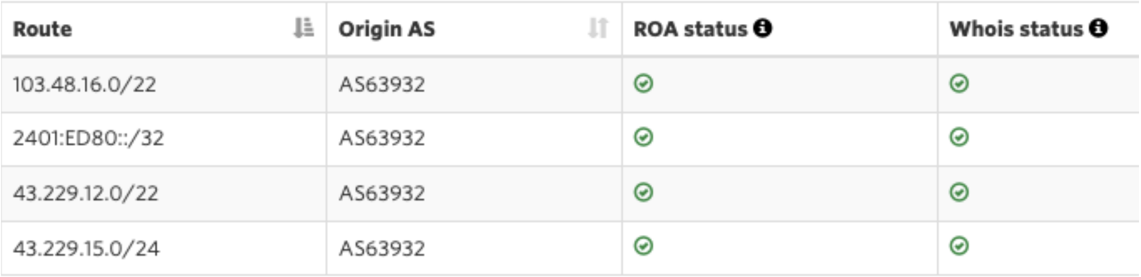
Sub-routes

Show 10 entries Search:

Route	Managed	Actions
103.48.16.0/22	Enabled	Update whois
103.48.16.0/23	Enabled	Update whois
103.48.16.0/24	Enabled	Update whois
103.48.17.0/24	Enabled	Update whois
103.48.18.0/23	Enabled	Update whois
103.48.18.0/24	Enabled	Update whois
103.48.19.0/24	Enabled	Update whois

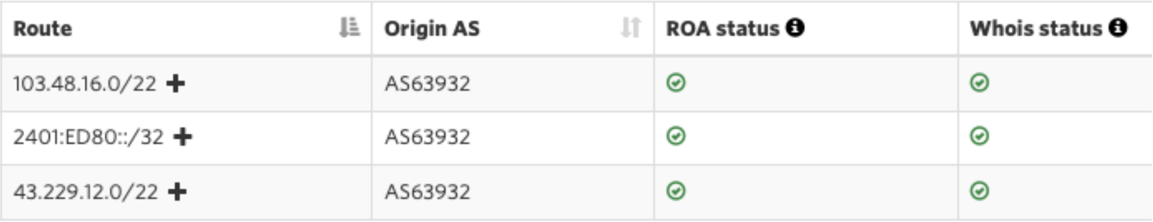
- Not a good idea to create ROAs up to /24 if not announced in BGP
- Better to create ROAs for specific prefixes that are announced in BGP

Creating ROA

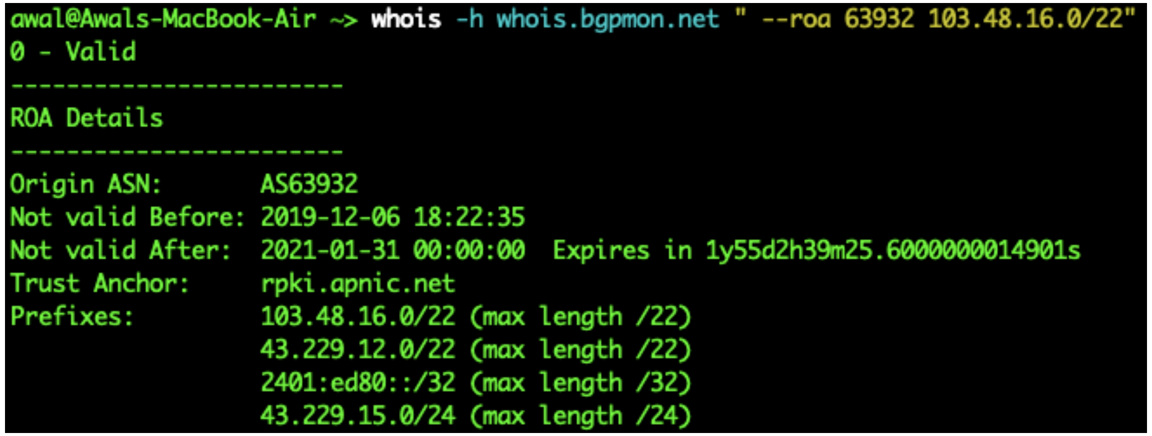


Route	Origin AS	ROA status	Whois status
103.48.16.0/22	AS63932	✓	✓
2401:ED80::/32	AS63932	✓	✓
43.229.12.0/22	AS63932	✓	✓
43.229.15.0/24	AS63932	✓	✓

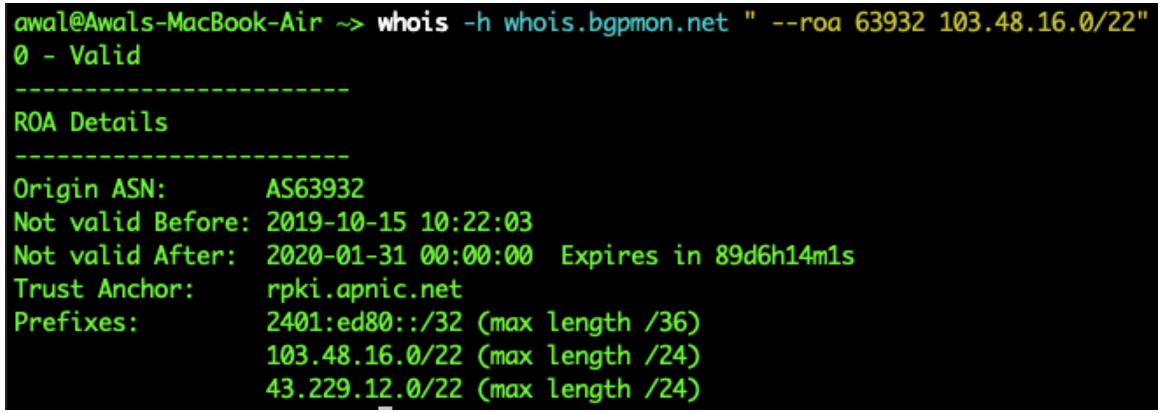
VS



Route	Origin AS	ROA status	Whois status
103.48.16.0/22 +	AS63932	✓	✓
2401:ED80::/32 +	AS63932	✓	✓
43.229.12.0/22 +	AS63932	✓	✓

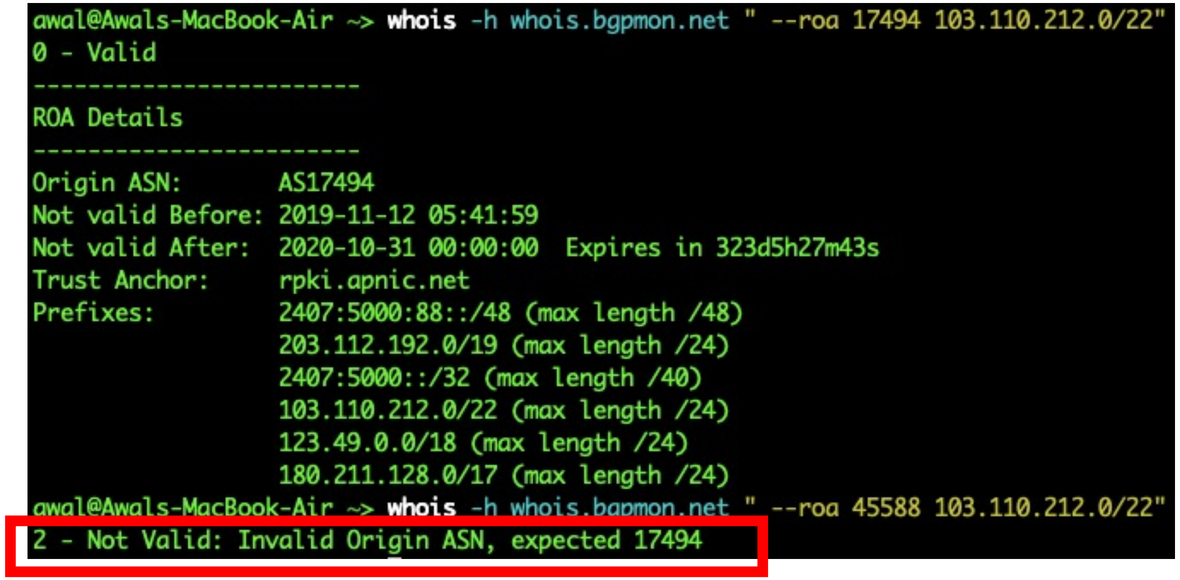


```
awal@Awals-MacBook-Air ~> whois -h whois.bgpmon.net " --roa 63932 103.48.16.0/22"
0 - Valid
------------------------
ROA Details
------------------------
Origin ASN:        AS63932
Not valid Before: 2019-12-06 18:22:35
Not valid After:  2021-01-31 00:00:00  Expires in 1y55d2h39m25.6000000014901s
Trust Anchor:     rpki.apnic.net
Prefixes:         103.48.16.0/22 (max length /22)
                  43.229.12.0/22 (max length /22)
                  2401:ed80::/32 (max length /32)
                  43.229.15.0/24 (max length /24)
```



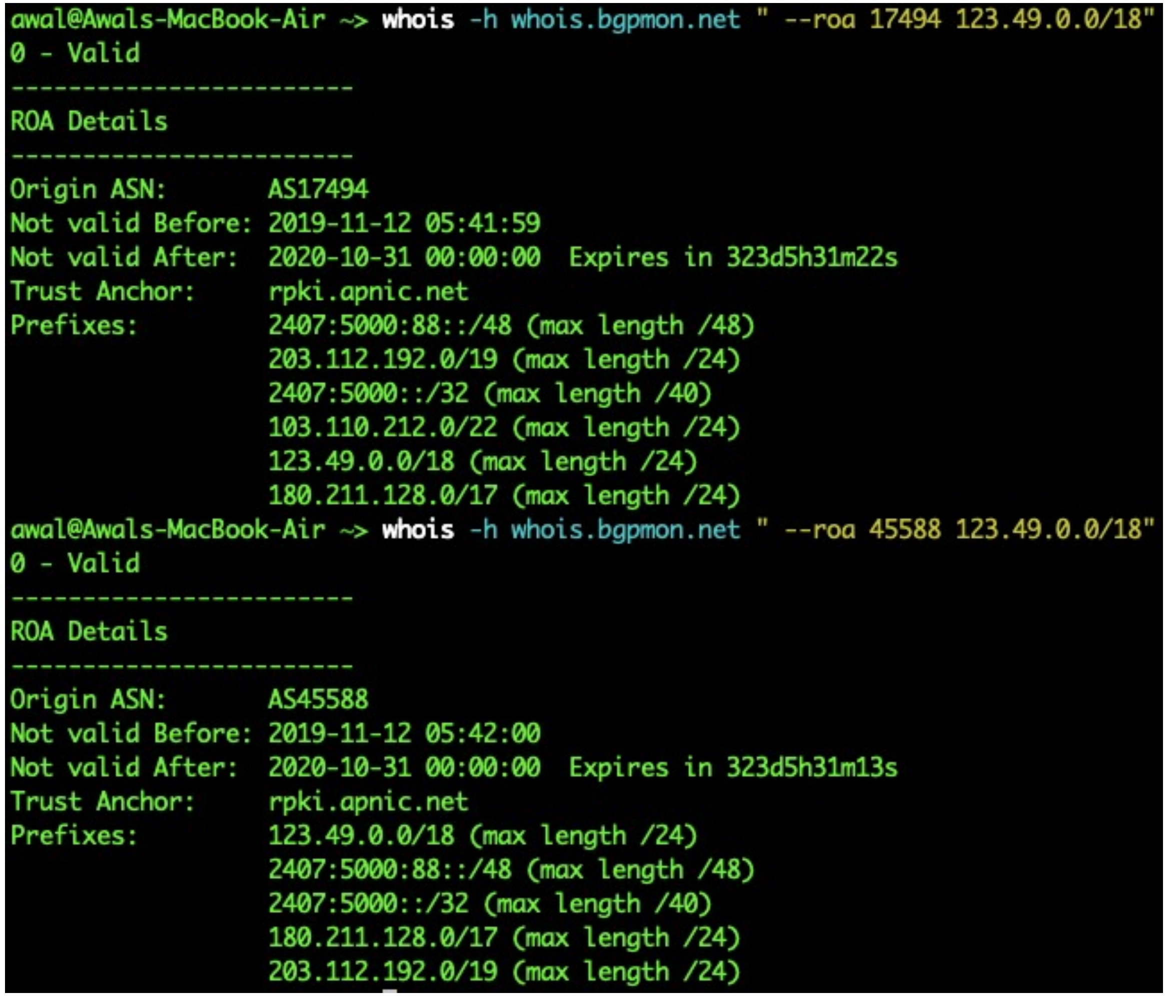
```
awal@Awals-MacBook-Air ~> whois -h whois.bgpmon.net " --roa 63932 103.48.16.0/22"
0 - Valid
------------------------
ROA Details
------------------------
Origin ASN:        AS63932
Not valid Before: 2019-10-15 10:22:03
Not valid After:  2020-01-31 00:00:00  Expires in 89d6h14m1s
Trust Anchor:     rpki.apnic.net
Prefixes:         2401:ed80::/32 (max length /36)
                  103.48.16.0/22 (max length /24)
                  43.229.12.0/22 (max length /24)
```

Creating ROA



```
awal@Awals-MacBook-Air ~> whois -h whois.bgpmon.net " --roa 17494 103.110.212.0/22"
0 - Valid
------------------------
ROA Details
------------------------
Origin ASN:       AS17494
Not valid Before: 2019-11-12 05:41:59
Not valid After:  2020-10-31 00:00:00  Expires in 323d5h27m43s
Trust Anchor:     rpki.apnic.net
Prefixes:         2407:5000:88::/48 (max length /48)
                  203.112.192.0/19 (max length /24)
                  2407:5000::/32 (max length /40)
                  103.110.212.0/22 (max length /24)
                  123.49.0.0/18 (max length /24)
                  180.211.128.0/17 (max length /24)
awal@Awals-MacBook-Air ~> whois -h whois.bgpmon.net " --roa 45588 103.110.212.0/22"
2 - Not Valid: Invalid Origin ASN, expected 17494
```

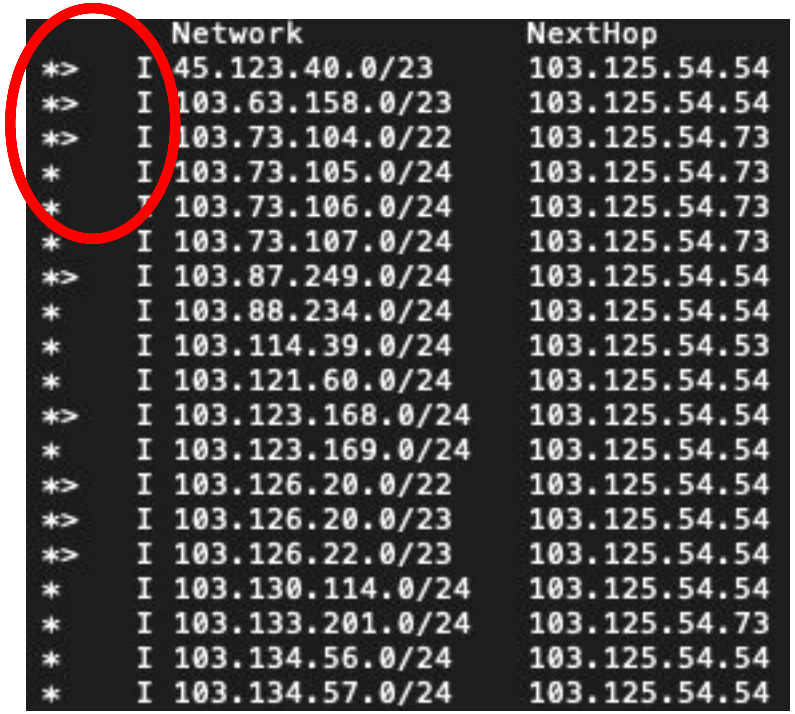
VS



```
awal@Awals-MacBook-Air ~> whois -h whois.bgpmon.net " --roa 17494 123.49.0.0/18"
0 - Valid
------------------------
ROA Details
------------------------
Origin ASN:       AS17494
Not valid Before: 2019-11-12 05:41:59
Not valid After:  2020-10-31 00:00:00  Expires in 323d5h31m22s
Trust Anchor:     rpki.apnic.net
Prefixes:         2407:5000:88::/48 (max length /48)
                  203.112.192.0/19 (max length /24)
                  2407:5000::/32 (max length /40)
                  103.110.212.0/22 (max length /24)
                  123.49.0.0/18 (max length /24)
                  180.211.128.0/17 (max length /24)
awal@Awals-MacBook-Air ~> whois -h whois.bgpmon.net " --roa 45588 123.49.0.0/18"
0 - Valid
------------------------
ROA Details
------------------------
Origin ASN:       AS45588
Not valid Before: 2019-11-12 05:42:00
Not valid After:  2020-10-31 00:00:00  Expires in 323d5h31m13s
Trust Anchor:     rpki.apnic.net
Prefixes:         123.49.0.0/18 (max length /24)
                  2407:5000:88::/48 (max length /48)
                  2407:5000::/32 (max length /40)
                  180.211.128.0/17 (max length /24)
                  203.112.192.0/19 (max length /24)
```

You may sign same prefix with multiple ASNs but do if you really really have to

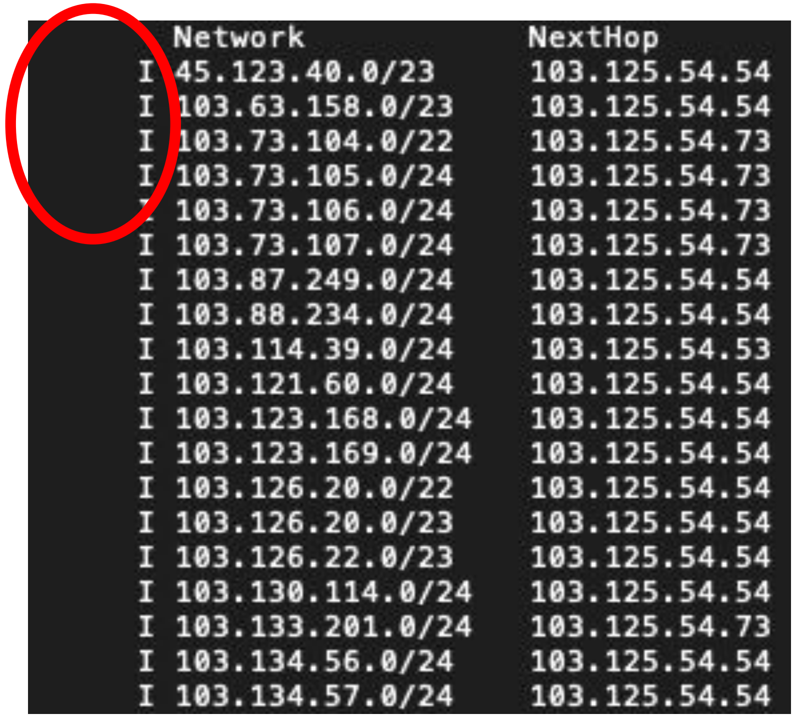
Doing ROV



```
         Network              NextHop
*>     I 45.123.40.0/23       103.125.54.54
*>     I 103.63.158.0/23      103.125.54.54
*>     I 103.73.104.0/22      103.125.54.73
*      I 103.73.105.0/24      103.125.54.73
*      I 103.73.106.0/24      103.125.54.73
*      I 103.73.107.0/24      103.125.54.73
*>     I 103.87.249.0/24      103.125.54.54
*      I 103.88.234.0/24      103.125.54.54
*      I 103.114.39.0/24      103.125.54.53
*      I 103.121.60.0/24      103.125.54.54
*>     I 103.123.168.0/24     103.125.54.54
*      I 103.123.169.0/24     103.125.54.54
*>     I 103.126.20.0/22      103.125.54.54
*>     I 103.126.20.0/23      103.125.54.54
*>     I 103.126.22.0/23      103.125.54.54
*      I 103.130.114.0/24     103.125.54.54
*      I 103.133.201.0/24     103.125.54.73
*      I 103.134.56.0/24      103.125.54.54
*      I 103.134.57.0/24      103.125.54.54
```

Validation with allowing invalids for BGP best path selection

VS



```
         Network              NextHop
       I 45.123.40.0/23       103.125.54.54
       I 103.63.158.0/23      103.125.54.54
       I 103.73.104.0/22      103.125.54.73
       I 103.73.105.0/24      103.125.54.73
       I 103.73.106.0/24      103.125.54.73
       I 103.73.107.0/24      103.125.54.73
       I 103.87.249.0/24      103.125.54.54
       I 103.88.234.0/24      103.125.54.54
       I 103.114.39.0/24      103.125.54.53
       I 103.121.60.0/24      103.125.54.54
       I 103.123.168.0/24     103.125.54.54
       I 103.123.169.0/24     103.125.54.54
       I 103.126.20.0/22      103.125.54.54
       I 103.126.20.0/23      103.125.54.54
       I 103.126.22.0/23      103.125.54.54
       I 103.130.114.0/24     103.125.54.54
       I 103.133.201.0/24     103.125.54.73
       I 103.134.56.0/24      103.125.54.54
       I 103.134.57.0/24      103.125.54.54
```

Validation without allowing invalids for BGP best path selection

ROA for Small ISPs and Enterprises

- Have own Internet resources?
  - Creating ROA is straightforward using RIR's resource management portal
- Got assignment for LIR?
  - Have public ASN?
    - Ask the LIR to create ROA with your ASN and verify
  - Don't have public ASN?
    - Ask the LIR to create ROA for the assigned prefix and verify

ROV for Small ISPs and Enterprises

- Have BGP with transits and peers?
  - Receive full routes from neighbors?
    - Implementing ROV using validator cache is straightforward
  - Receive partial routes with default from neighbors?
    - Ask transits to do ROV for you
    - And, implement ROV using validator cache to validate peer and IX routes
  - Receive default route only
    - ROV wouldn’t fit, however, you may ask transits to do ROV in their routers ☺
- Have static routing with transits?
  - ROV wouldn’t fit, however, you may ask transits to do ROV in their routers ☺

Still thinking why we need ROA and ROV?

- Check the issues discussed in first couple slides
- Reduce the opportunity of routing incidents, prefix hijacks, route leaks, DDoS, outages
- You wouldn’t want to be a target of those incidents
- Help improve global routing infrastructure security
- Help each other to maintain routing hygiene
- We are engineers working hard to make Internet better, remember?

We all can help improve global routing security

- Create/fix ROAs for your prefixes
- If you are a transit provider, ask you clients to do the same
- If you're receiving BGP full route, implement ROV
- Share this among other colleagues in the community
- Help others fix their ROAs

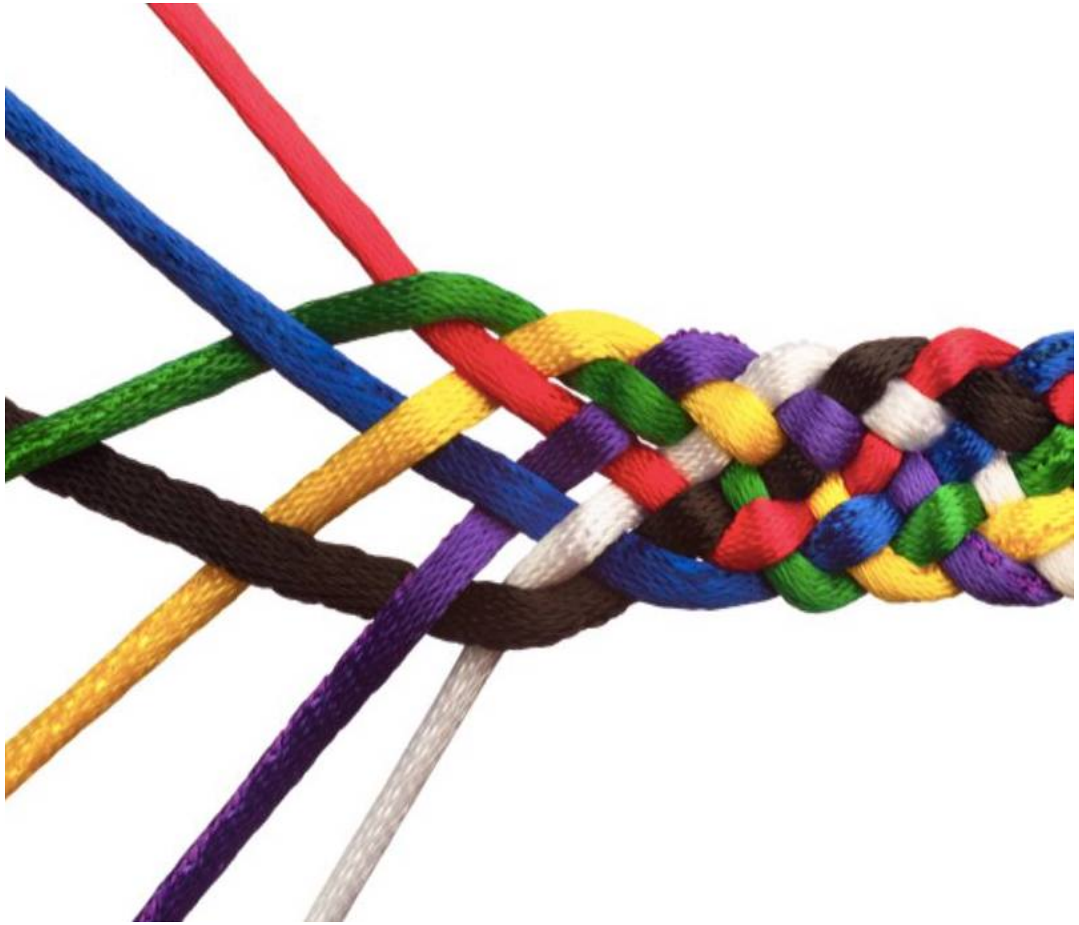


Image source: Internet

Let’s check your own ASN

- Go to https://bgp.he.net , search for your AS number and check v4 and v6 prefixes

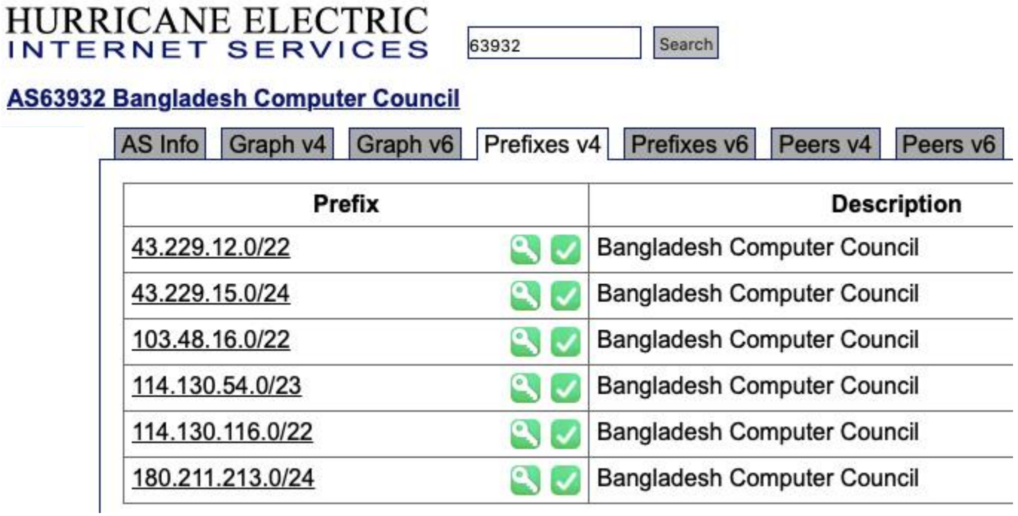
Or,

- Use whois on unix terminal:

```
whois -h whois.bgpmon.net " --roa ASN Prefix"
```

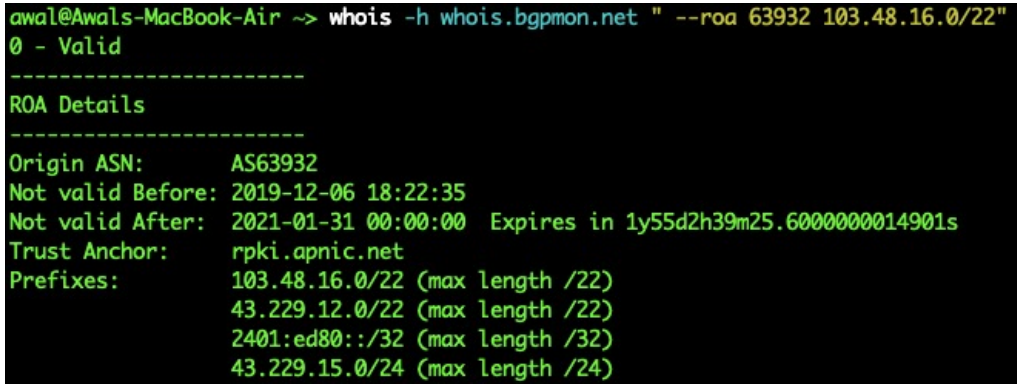
- If you find issues with ROA, please fix it

https://blog.apnic.net/2019/09/11/how-to-creating-rpki-roas-in-myapnic/



AS63932 Bangladesh Computer Council

Prefix	Description
43.229.12.0/22 🔍 ✓	Bangladesh Computer Council
43.229.15.0/24 🔍 ✓	Bangladesh Computer Council
103.48.16.0/22 🔍 ✓	Bangladesh Computer Council
114.130.54.0/23 🔍 ✓	Bangladesh Computer Council
114.130.116.0/22 🔍 ✓	Bangladesh Computer Council
180.211.213.0/24 🔍 ✓	Bangladesh Computer Council



```
awal@Awals-MacBook-Air ~> whois -h whois.bgpmon.net " --roa 63932 103.48.16.0/22"
0 - Valid
------------------------
ROA Details
------------------------
Origin ASN:         AS63932
Not valid Before: 2019-12-06 18:22:35
Not valid After:  2021-01-31 00:00:00  Expires in 1y55d2h39m25.6000000014901s
Trust Anchor:       rpki.apnic.net
Prefixes:           103.48.16.0/22 (max length /22)
                    43.229.12.0/22 (max length /22)
                    2401:ed80::/32 (max length /32)
                    43.229.15.0/24 (max length /24)
```

References

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6. https://www.apnic.net/community/security/resource-certification/
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8. https://blog.apnic.net/2019/09/11/how-to-creating-rpki-roas-in-myapnic/
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Questions?