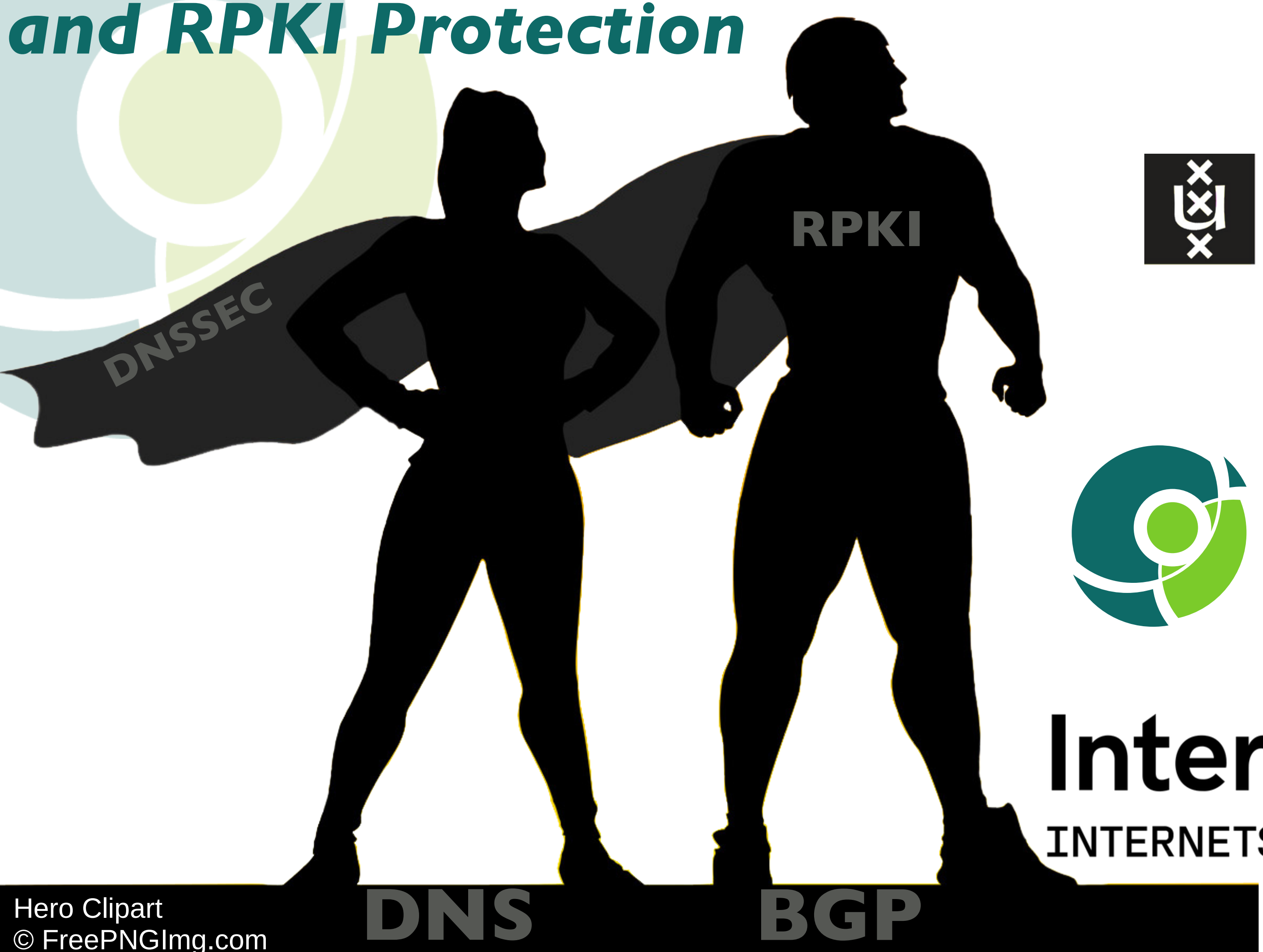
The Current State of DNS Resolvers and RPKI Protection



Hero Clipart
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University of Amsterdam

Erik Dekker

Marius Brouwer

NLNETLABS

Willem Toorop

Internetdagarna

INTERNETSTIFTELSEN

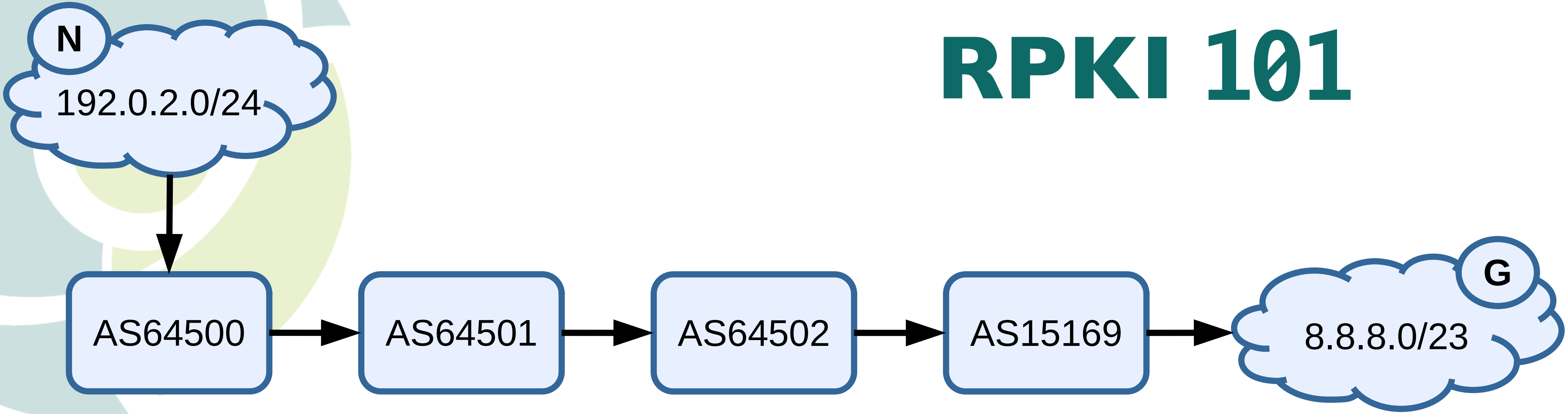
23 November 2020

Motivation

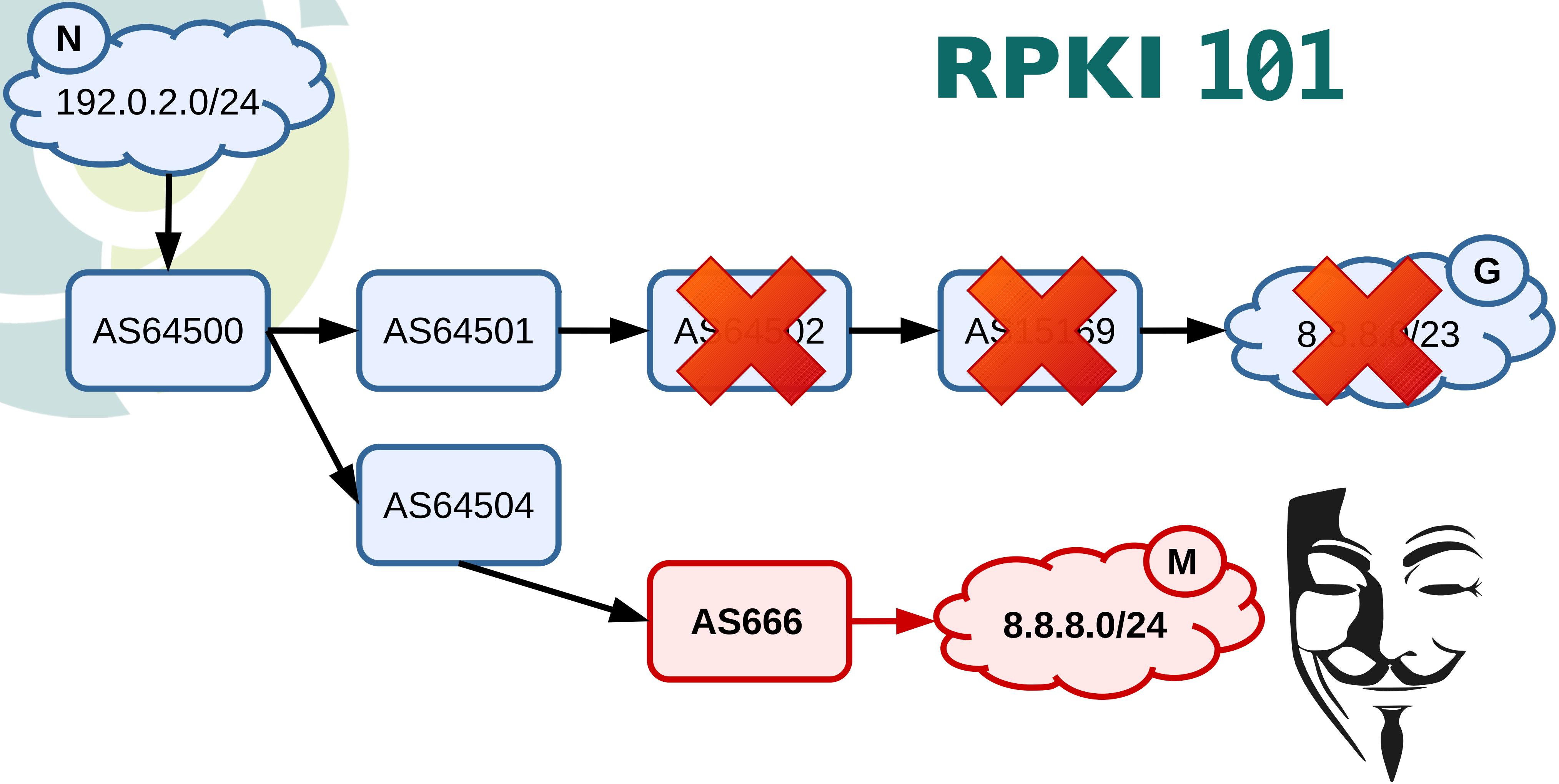
- DNSSEC protects against address forgery
- But the address can be trivially hijacked

Picture CC BY-SA 3.0
by Vegas Bleeds Neon

RPKI 101



RPKI 101

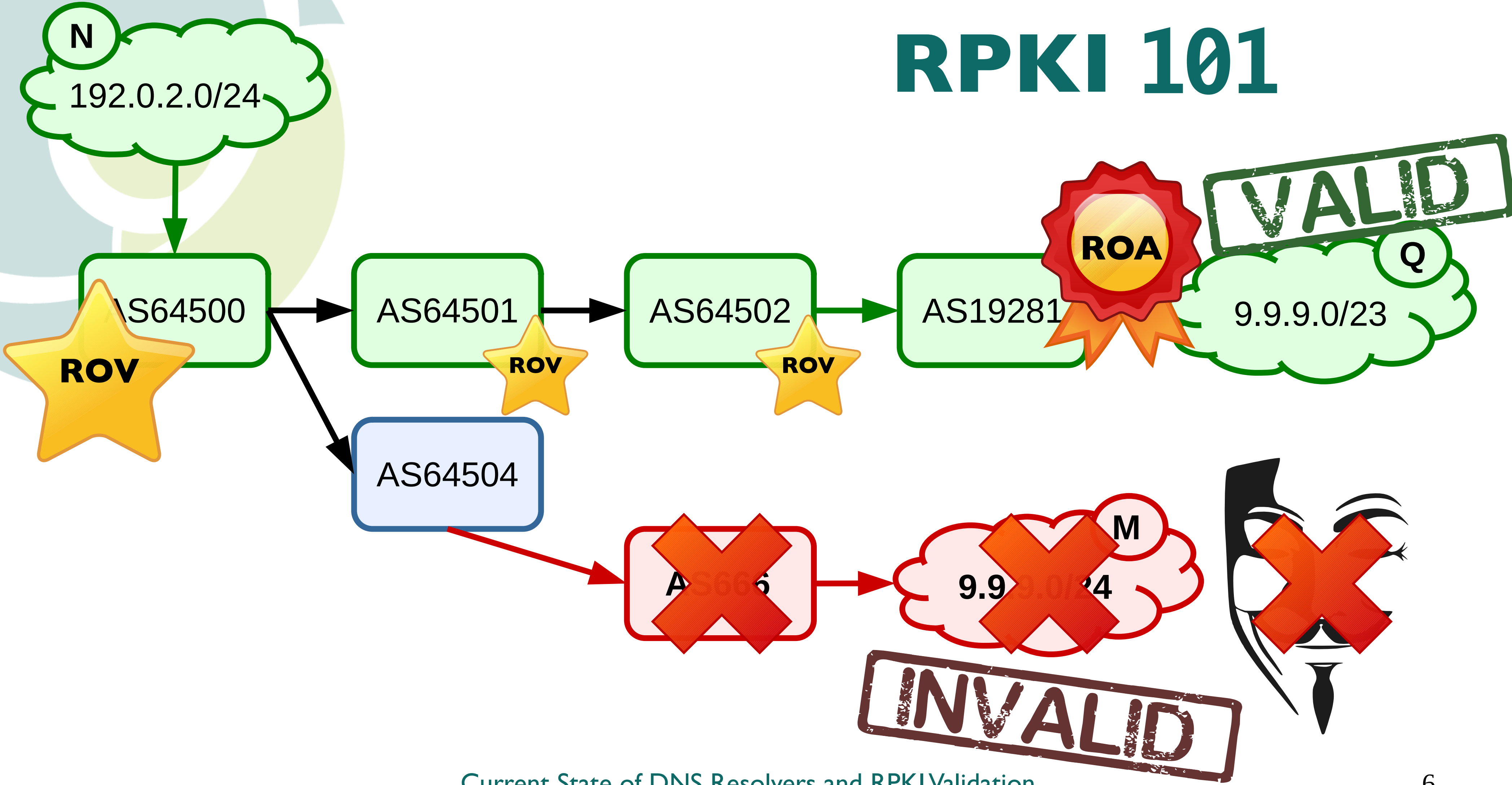

N
192.0.2.0/24
AS64500
AS64501
AS64502
AS15169
8.8.8.0/23
G
AS64504
AS666
8.8.8.0/24
M

Motivation

- DNSSEC protects against address forgery
- But the address
  can be trivially hijacked
- RPKI to the rescue

Picture CC BY-SA 3.0
by Vegas Bleeds Neon

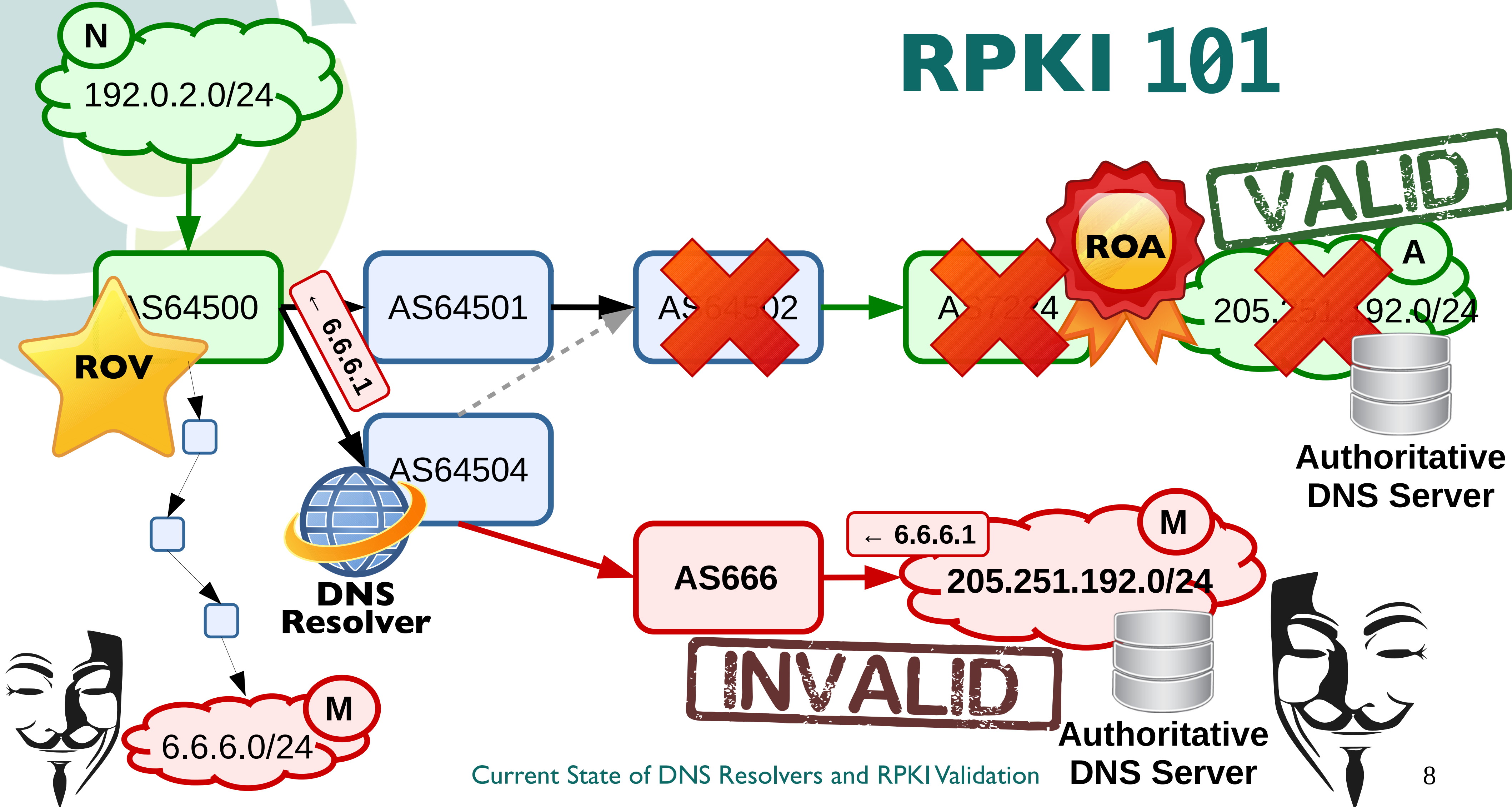
RPKI 101

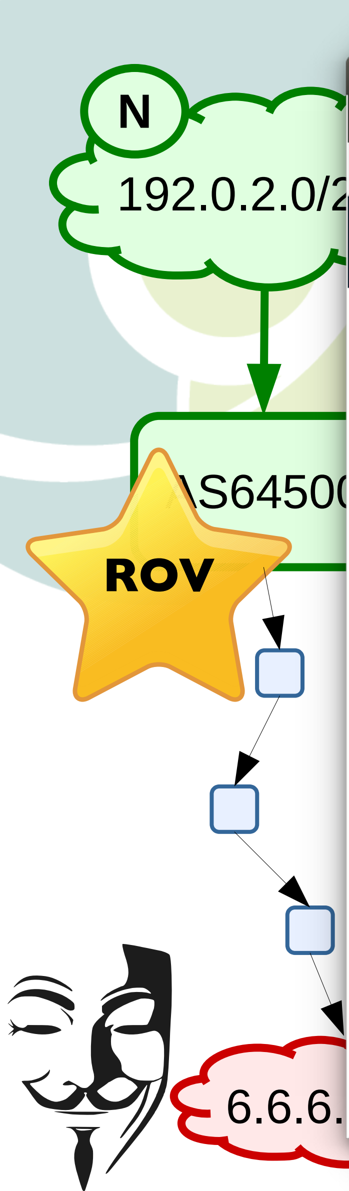

N
192.0.2.0/24
AS64500
ROV
AS64501
ROV
AS64502
ROV
AS19281
ROA
VALID
Q
9.9.9.0/23
AS64504
AS666
M
9.9.9.0/24
INVALID

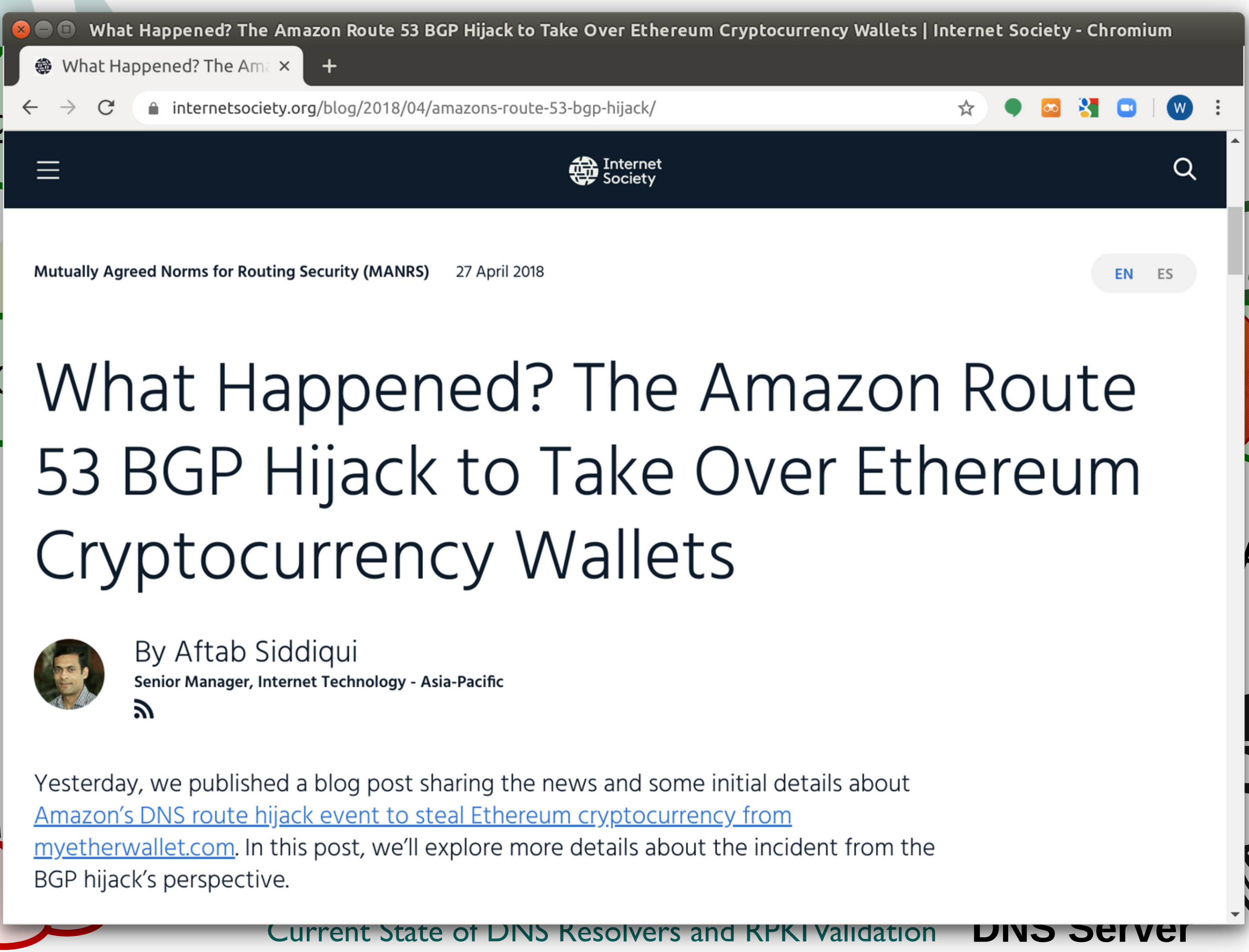
Motivation

- What does this have to do with DNS Resolvers?

RPKI 101


N
192.0.2.0/24
AS64500
ROV
← 6.6.6.1
AS64501
AS64502
AS7224
ROA
VALID
A
205.251.192.0/24
Authoritative DNS Server
AS64504
DNS Resolver
AS666
← 6.6.6.1
M
205.251.192.0/24
INVALID
Authoritative DNS Server
M
6.6.6.0/24




What Happened? The Amazon Route 53 BGP Hijack to Take Over Ethereum Cryptocurrency Wallets | Internet Society - Chromium
What Happened? The Am
internetsociety.org/blog/2018/04/amazons-route-53-bgp-hijack/
Internet Society
EN ES

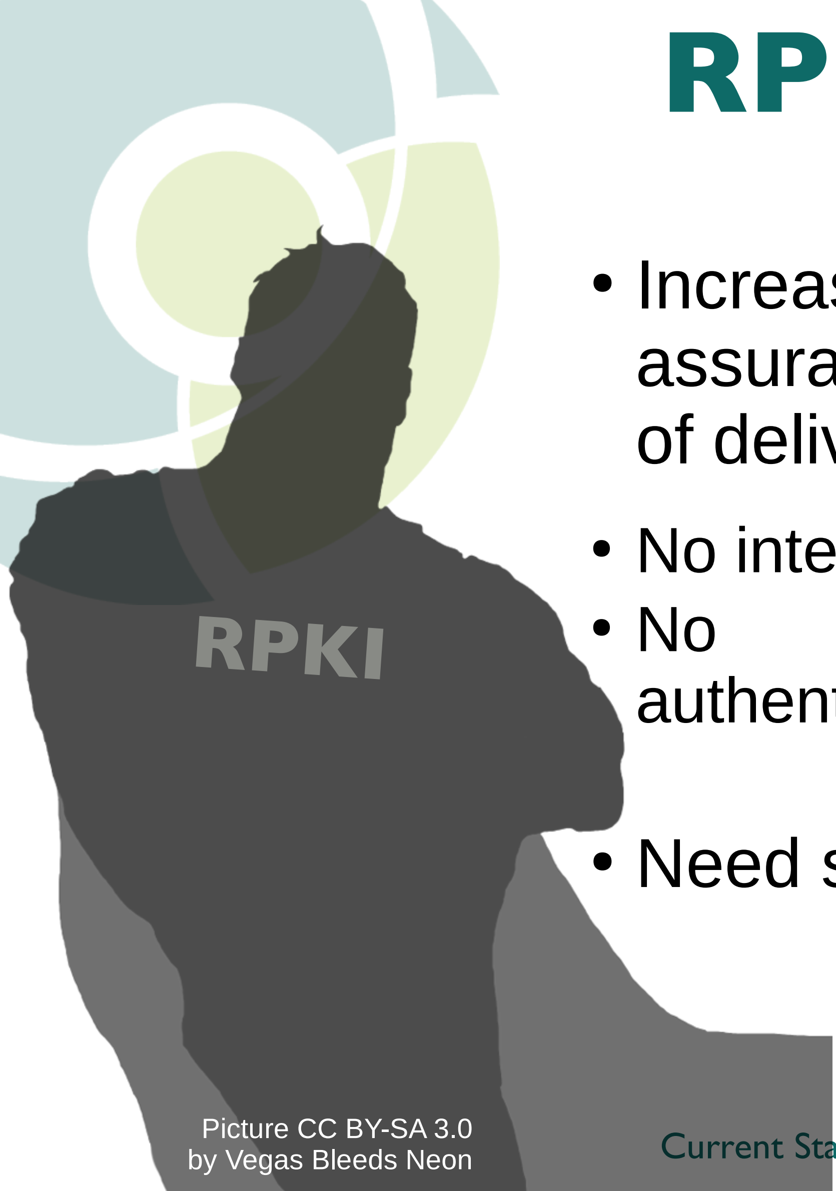
Mutually Agreed Norms for Routing Security (MANRS) 27 April 2018

What Happened? The Amazon Route 53 BGP Hijack to Take Over Ethereum Cryptocurrency Wallets

By Aftab Siddiqui
Senior Manager, Internet Technology - Asia-Pacific

Yesterday, we published a blog post sharing the news and some initial details about Amazon's DNS route hijack event to steal Ethereum cryptocurrency from myetherwallet.com. In this post, we'll explore more details about the incident from the BGP hijack's perspective.

RPKI & DNSSEC



Picture CC BY-SA 3.0
by Vegas Bleeds Neon

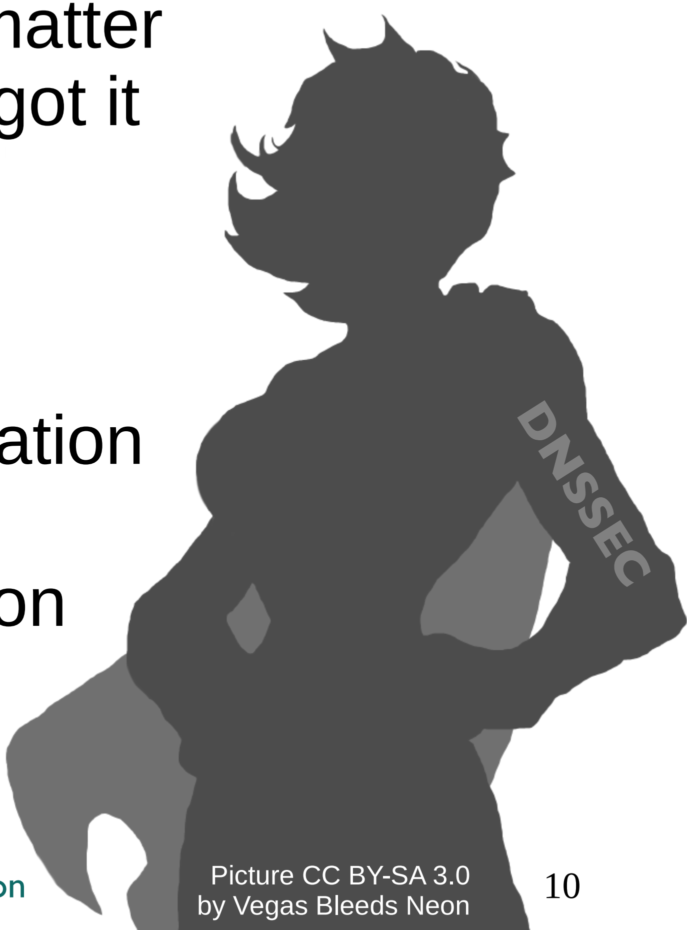
- Increase assurance of delivery

- No integrity
- No authentication

- Doesn’t matter how you got it

- Integrity
- Origin authentication

- Need signing **and** validation



Picture CC BY-SA 3.0
by Vegas Bleeds Neon

Research question

Main:

What is the state of Route Origin Validation (RoV) on DNS resolvers?

Sub:

- Does the length of the AS path matter?
- How does anycast influence the protection?

Test setup

```
$ORIGIN rootcanary.net
$TTL 60
@    SOA  ns1.surfnet.nl. (
          dns-beheer.surfnet.nl.
          2020080503 ; serial
          10800      ; refresh
          3600       ; retry
          604800     ; expire
          86400      ; minimum
          )
     NS   ns1.surfnet.nl.
     NS   ns2.surfnet.nl.
     NS   ns3.surfnet.nl.
     NS   ns1.zurich.surf.net.

$TTL 25200

valid4    NS   valid4
valid4    A    209.24.1.6

invalid4  NS   invalid4
invalid4  A    194.32.71.6
```

```
$ORIGIN valid4.rootcanary.net
$TTL 300
@          SOA  valid4.rootcanary.net. (
                sysadm.rootcanary.org.
                2020012100 10800 3600
                604800 300 )
           NS   @
           A    209.24.1.6
$TTL 1
invalid    DNAME invalid4.rootcanary.net.
```

prefix	209.24.1.0/24
max len	24
ASN	15562

ROA

VALID

```
$ORIGIN invalid4.rootcanary.net
$TTL 300
@          SOA  invalid4.rootcanary.net. (
                sysadm.rootcanary.org.
                2020012100 10800 3600
                604800 300 )
           NS   @
           A    194.32.71.6
*          A    145.97.20.20
```

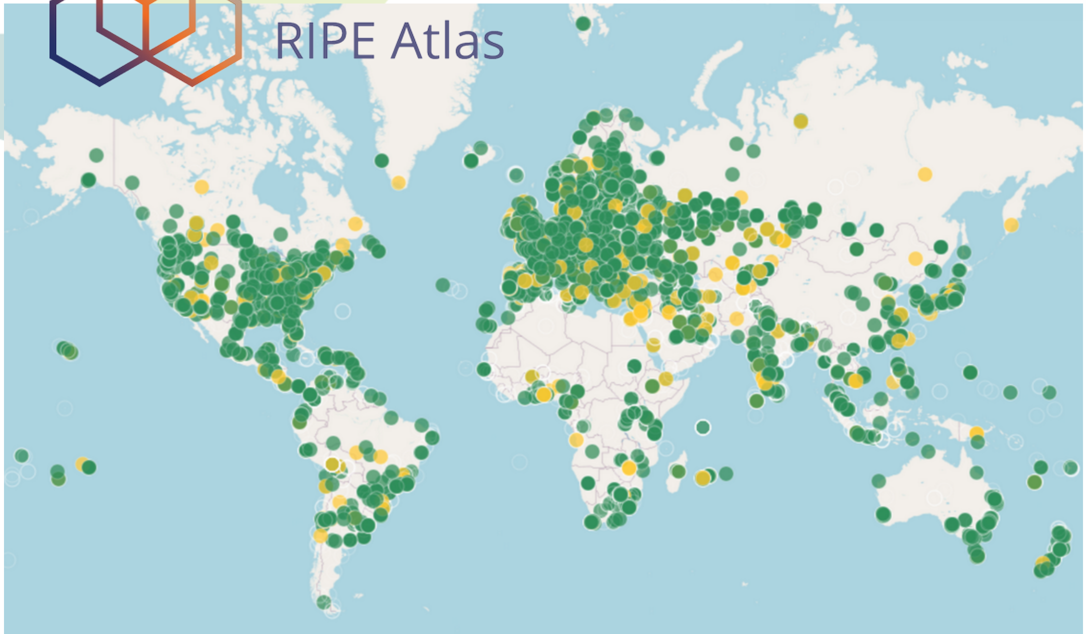
prefix	194.32.71.0/24
max len	24
ASN	0

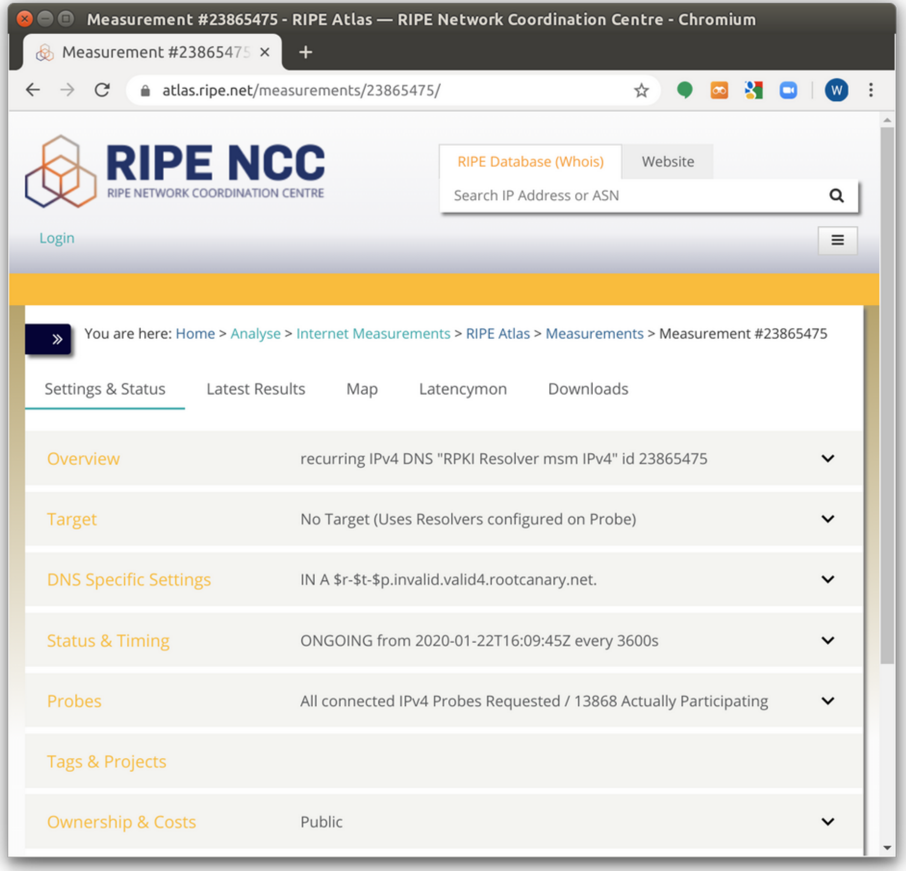
ROA

INVALID

Test setup

RIPE NCC
RIPE Atlas

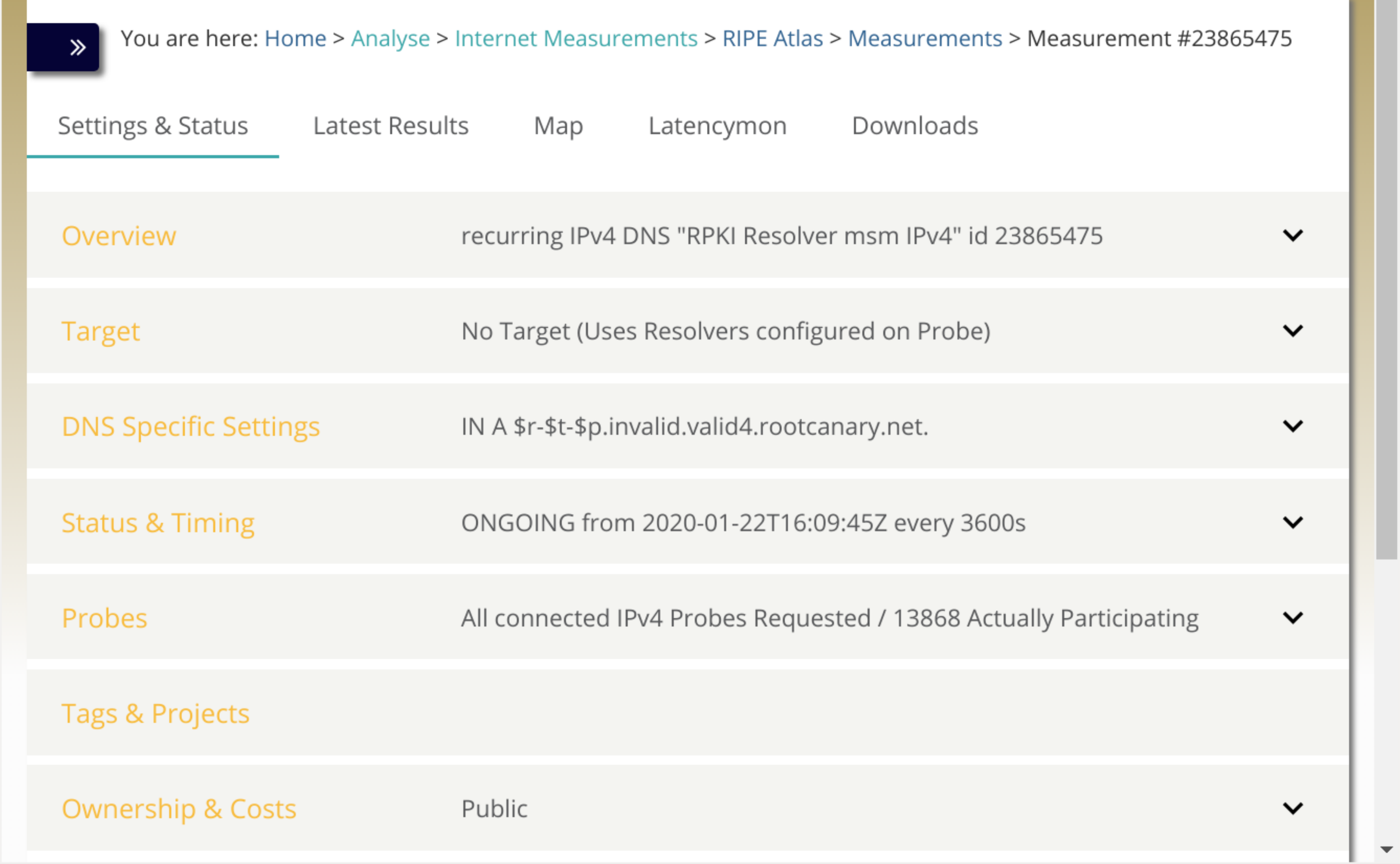



Measurement #23865475 - RIPE Atlas — RIPE Network Coordination Centre - Chromium
Measurement #23865475
atlas.ripe.net/measurements/23865475/
RIPE NCC
RIPE NETWORK COORDINATION CENTRE
RIPE Database (Whois)
Website
Search IP Address or ASN
Login

You are here: Home > Analyse > Internet Measurements > RIPE Atlas > Measurements > Measurement #23865475

Settings & Status | Latest Results | Map | Latencymon | Downloads

Overview	recurring IPv4 DNS "RPKI Resolver msm IPv4" id 23865475
Target	No Target (Uses Resolvers configured on Probe)
DNS Specific Settings	IN A $r-$t-$p.invalid.valid4.rootcanary.net.
Status & Timing	ONGOING from 2020-01-22T16:09:45Z every 3600s
Probes	All connected IPv4 Probes Requested / 13868 Actually Participating
Tags & Projects	
Ownership & Costs	Public



You are here: Home > Analyse > Internet Measurements > RIPE Atlas > Measurements > Measurement #23865475

Overview	recurring IPv4 DNS "RPKI Resolver msm IPv4" id 23865475
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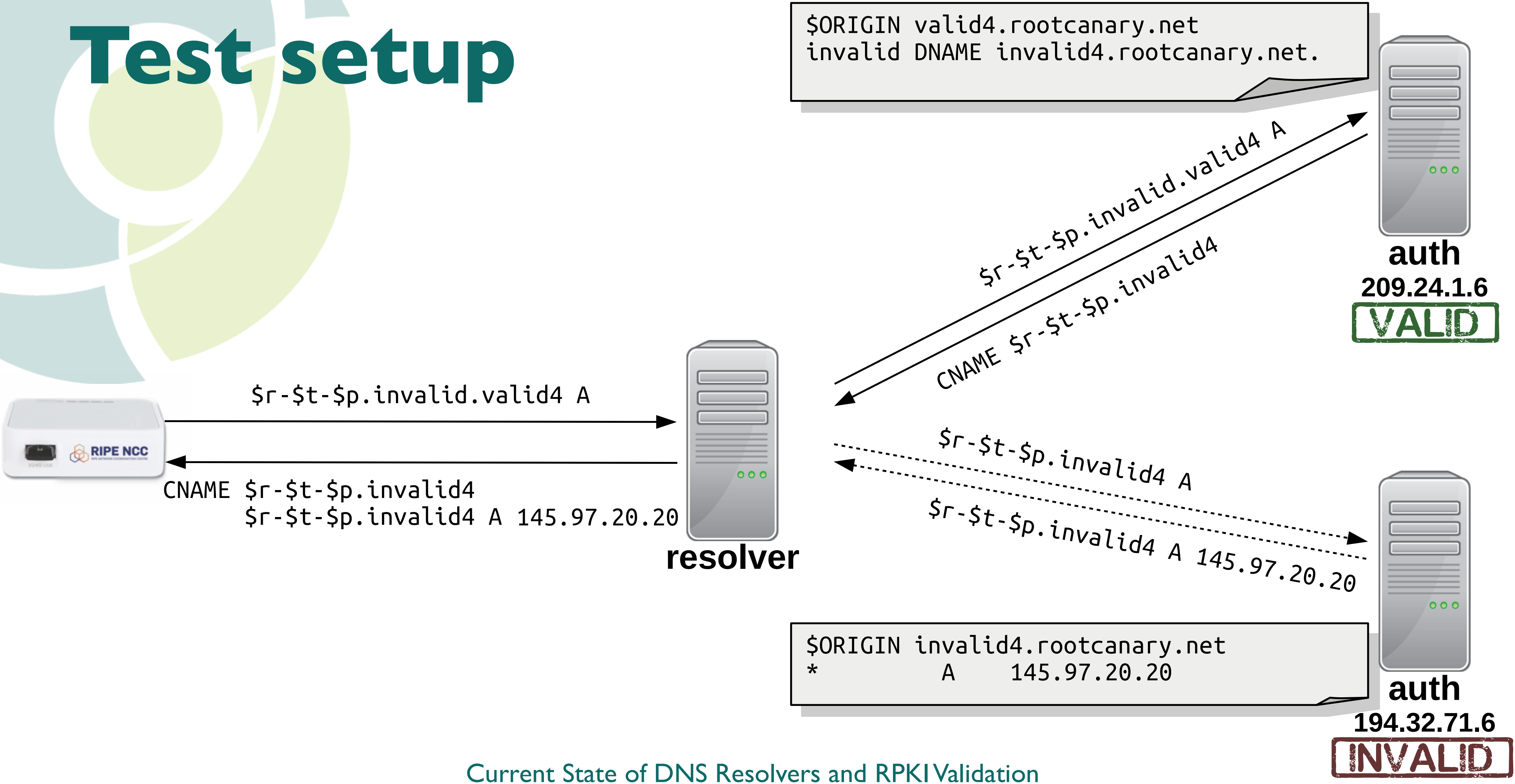
Status & Timing	ONGOING from 2020-01-22T16:09:45Z every 3600s
Probes	All connected IPv4 Probes Requested / 13868 Actually Participating
Tags & Projects	
Ownership & Costs	Public

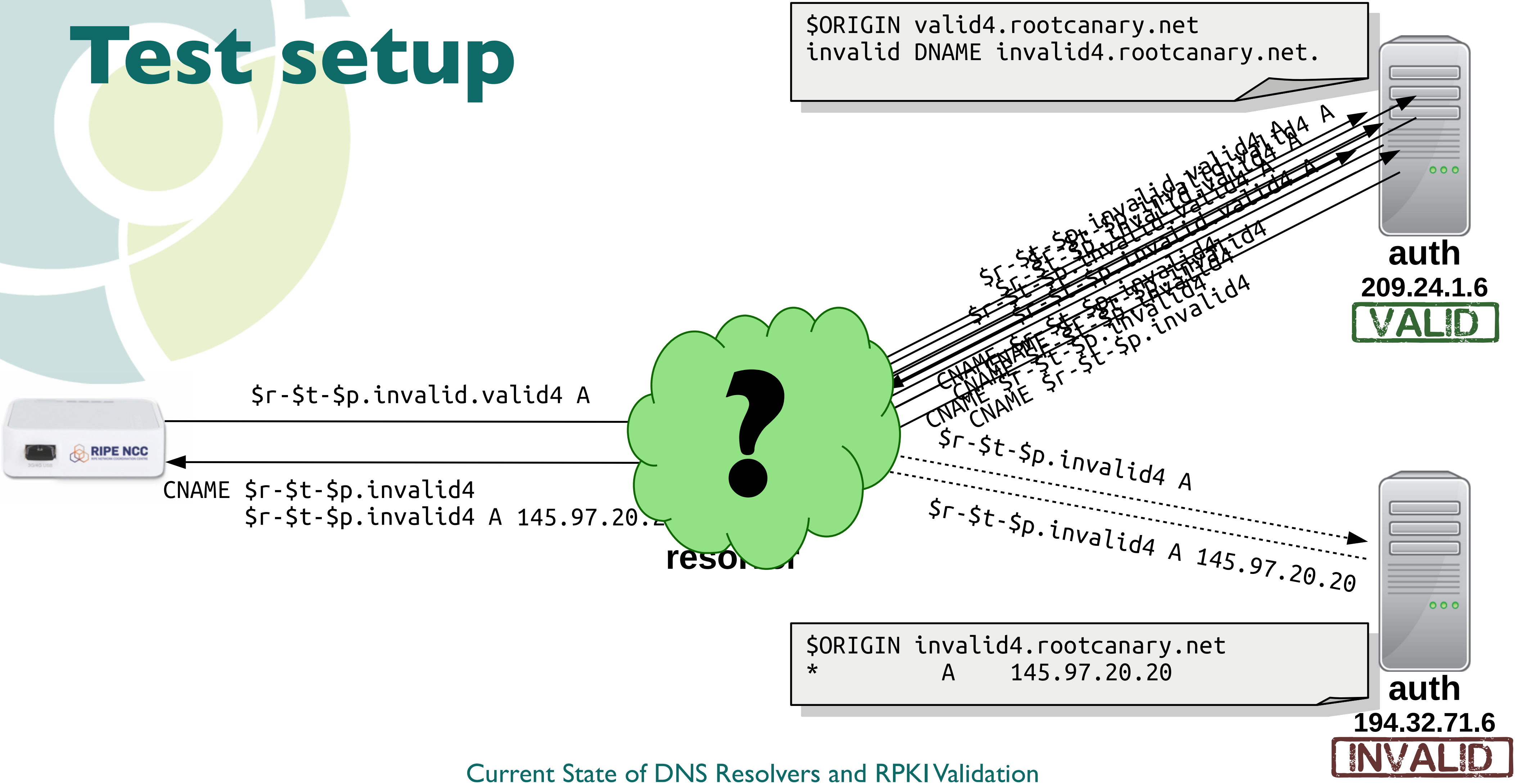
Test setup



```
$ORIGIN valid4.rootcanary.net
invalid DNAME invalid4.rootcanary.net.
```

```
$ORIGIN invalid4.rootcanary.net
*          A    145.97.20.20
```

Test setup



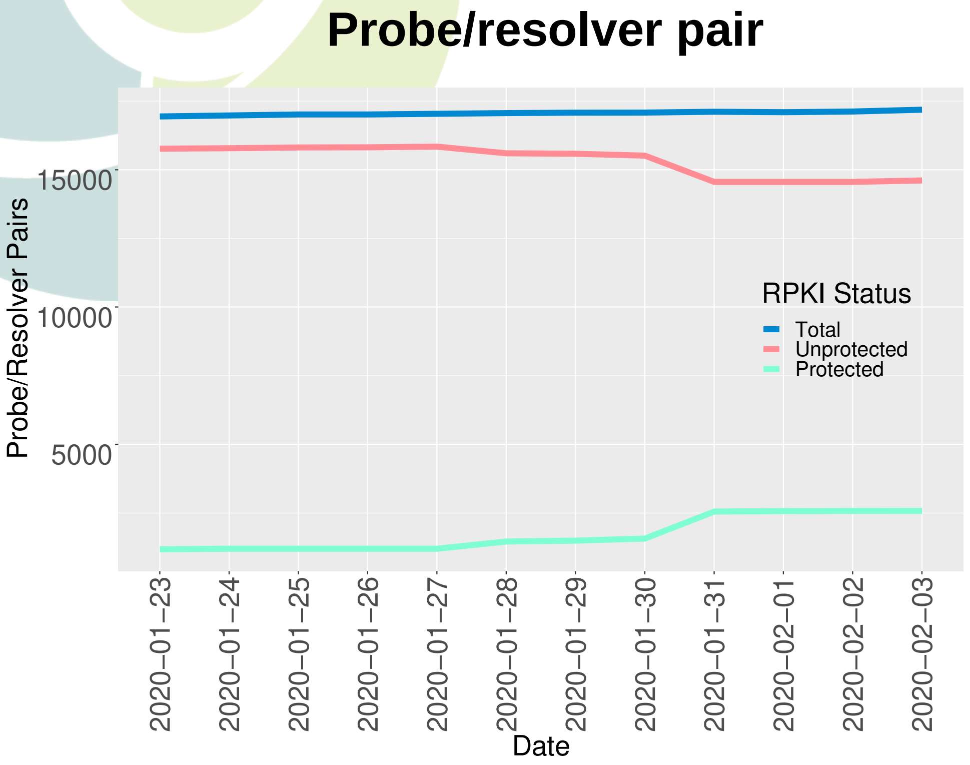
```
$ORIGIN valid4.rootcanary.net
invalid DNAME invalid4.rootcanary.net.
```

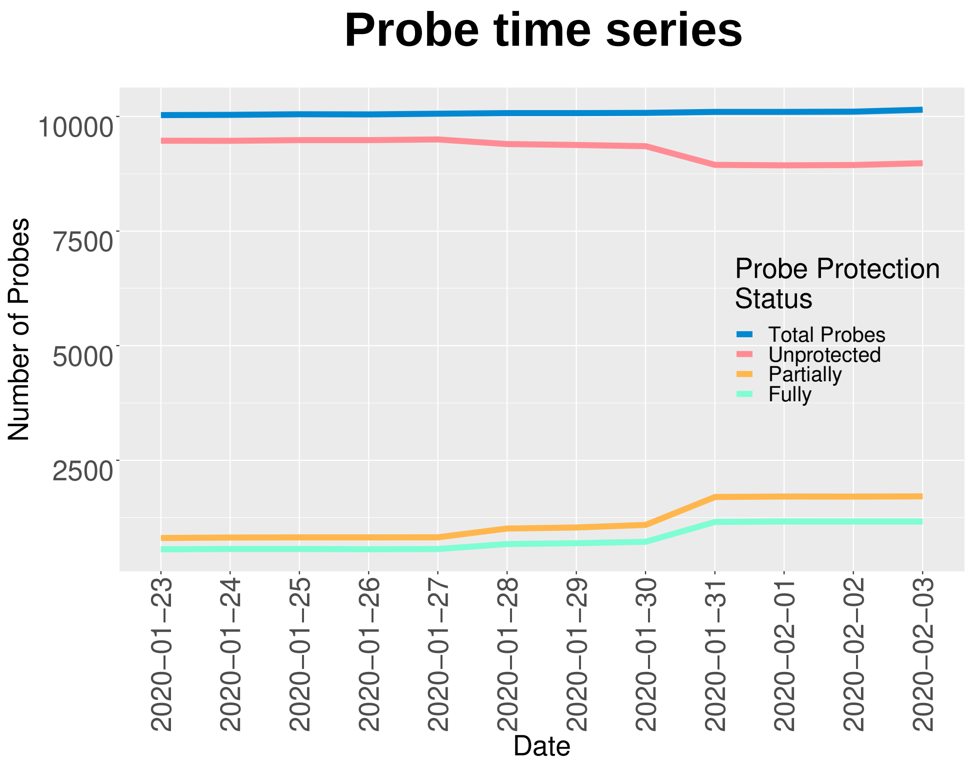
```
$ORIGIN invalid4.rootcanary.net
*           A     145.97.20.20
```

Test setup

- Atlas measurement
  kindly provided by Emile Aben
- Beacon for the authoritatives
  kindly provided by Job Snijders

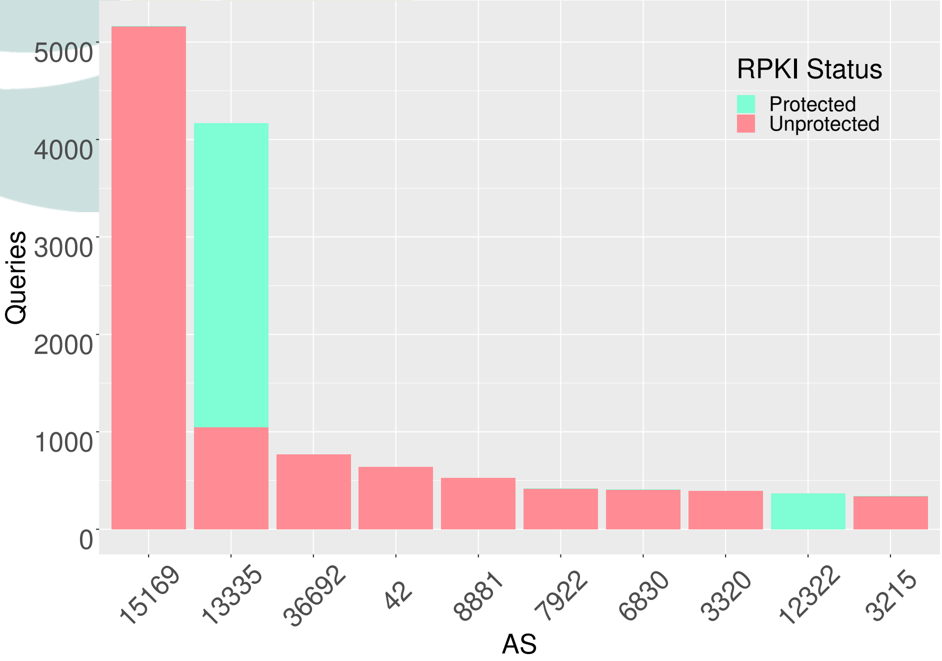
Results


Probe/resolver pair
Probe/Resolver Pairs
15000
10000
5000
RPKI Status
Total
Unprotected
Protected
2020–01–23
2020–01–24
2020–01–25
2020–01–26
2020–01–27
2020–01–28
2020–01–29
2020–01–30
2020–01–31
2020–02–01
2020–02–02
2020–02–03
Date

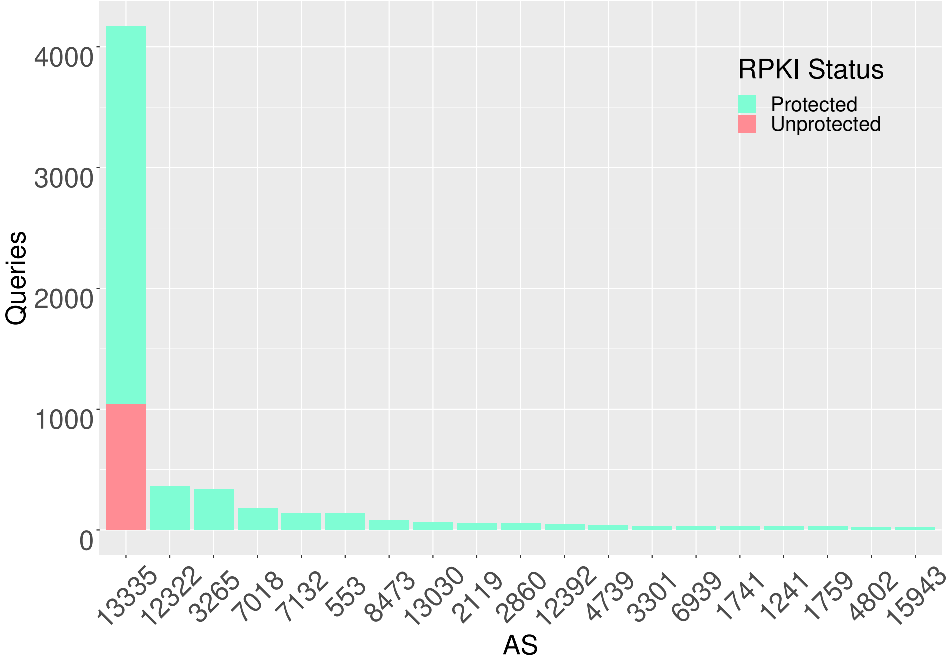

Probe time series
Number of Probes
10000
7500
5000
2500
Probe Protection Status
Total Probes
Unprotected
Partially
Fully
2020–01–23
2020–01–24
2020–01–25
2020–01–26
2020–01–27
2020–01–28
2020–01–29
2020–01–30
2020–01–31
2020–02–01
2020–02–02
2020–02–03
Date

Results

Top ten most popular ASes



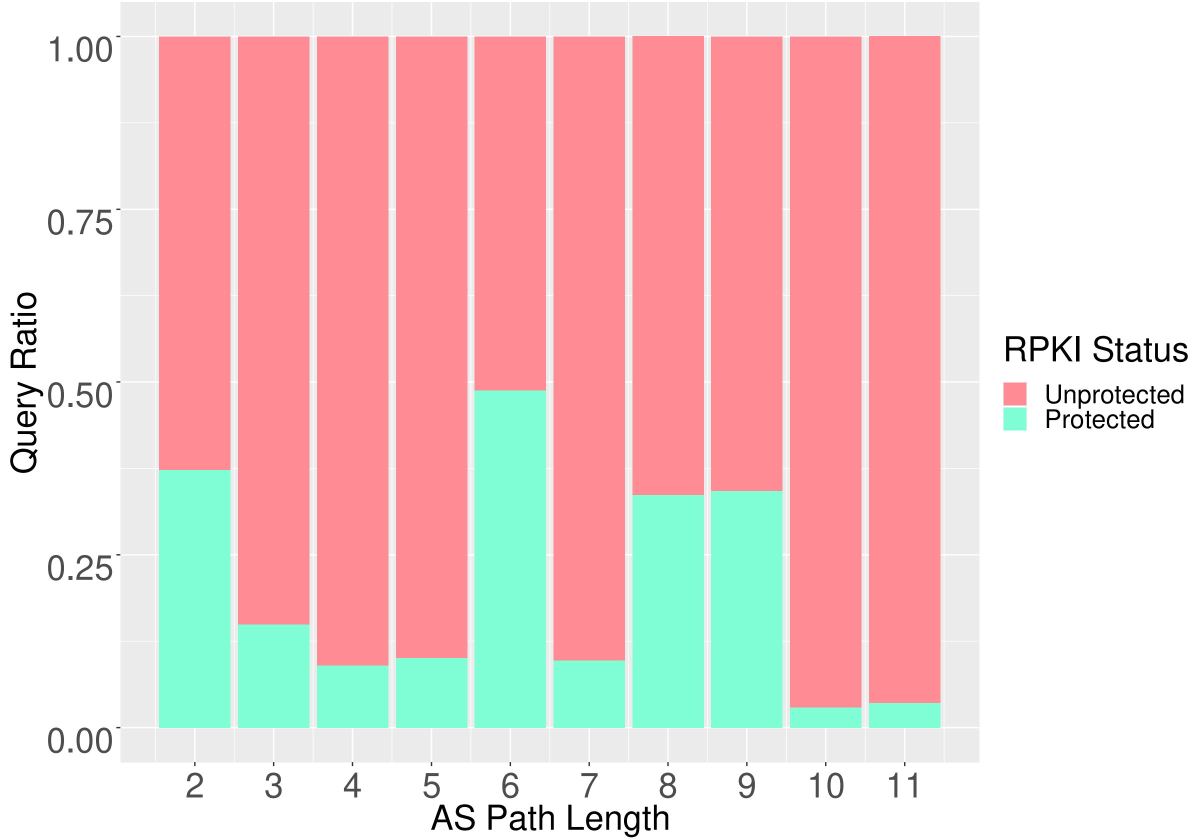
Top ten most protected ASes



Results

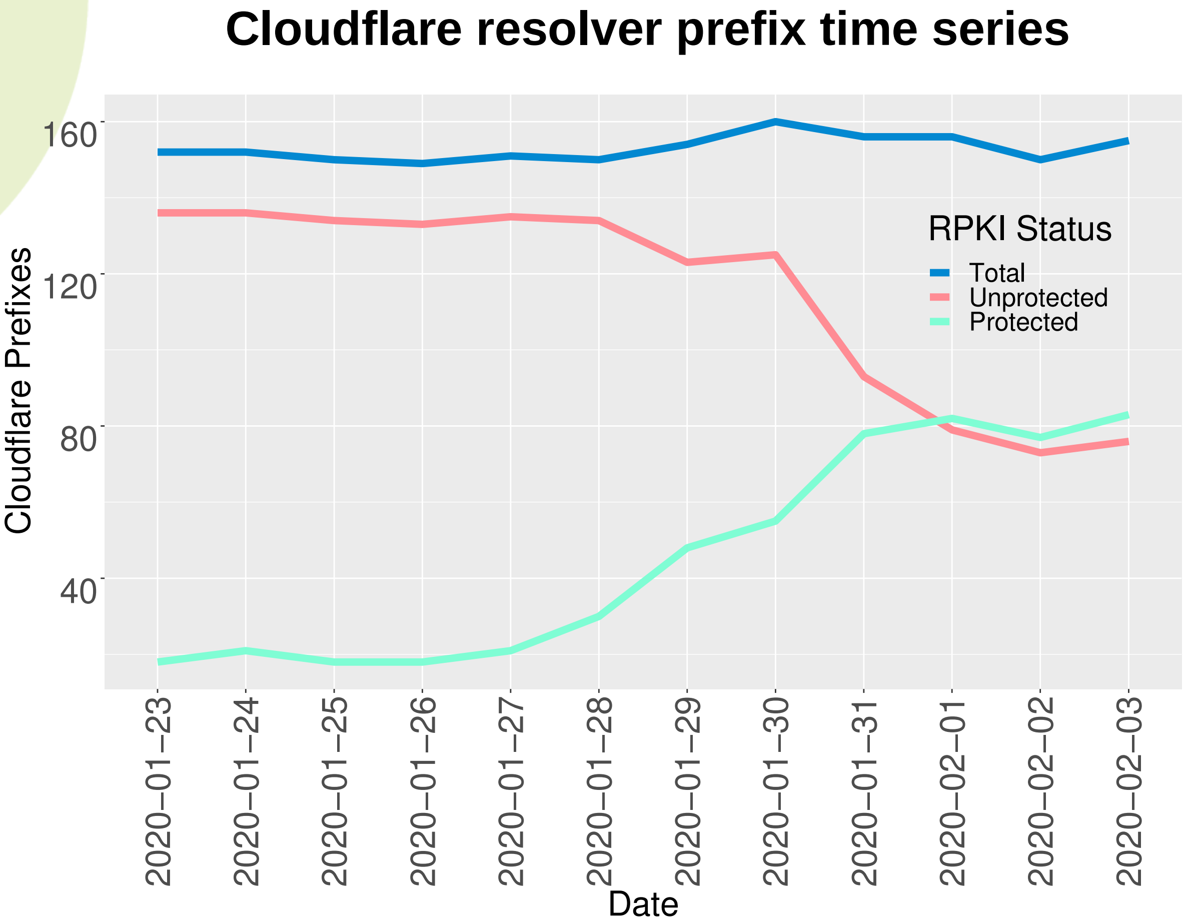
Sub RQ: Does the length of the AS path matter?

Relationship RPKI protection and AS path length



Results

Sub RQ: How does anycast influence protection?



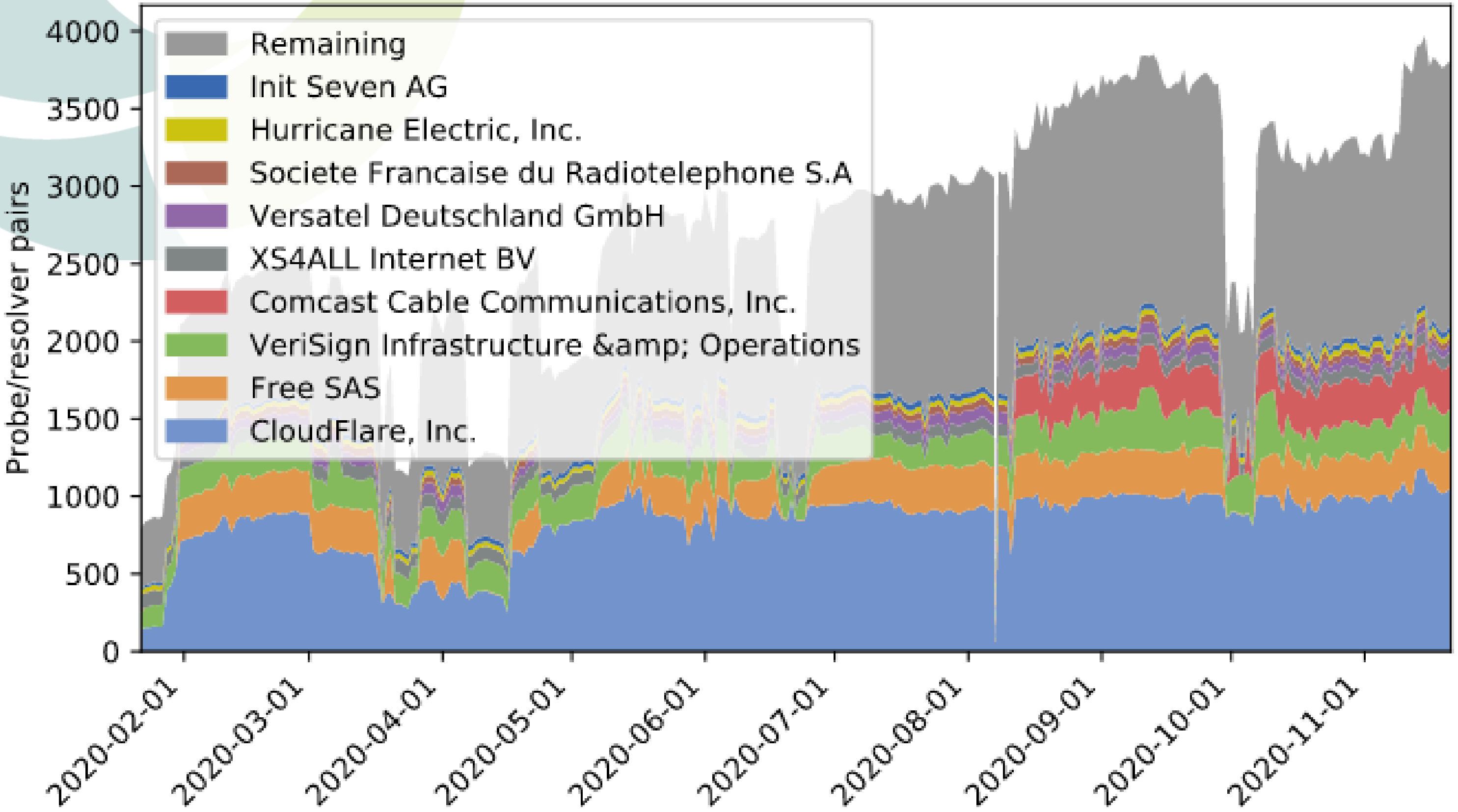
Current situation / IPv6

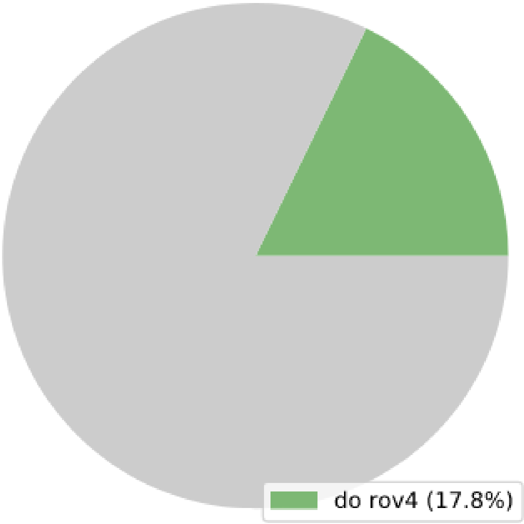
53

DNSThought

DNSThought

https://dnsthought.nlnetlabs.nl/does_rov4/#top_auth_asns





Test setup

```
$ORIGIN rootcanary.net
$TTL 60
@    SOA  ns1.surfnet.nl. (
          dns-beheer.surfnet.nl.
          2020080503 ; serial
          10800      ; refresh
          3600       ; retry
          604800     ; expire
          86400      ; minimum
          )
     NS   ns1.surfnet.nl.
     NS   ns2.surfnet.nl.
     NS   ns3.surfnet.nl.
     NS   ns1.zurich.surf.net.

$TTL 25200

valid6    NS   valid6
valid6    AAAA 2001:728:1808:5::6

invalid6  NS   invalid6
invalid6  AAAA 2001:7fb:fd04::6
```

```
$ORIGIN valid6.rootcanary.net
$TTL 300
@         SOA  valid6.rootcanary.net. (
               sysadm.rootcanary.org.
               2020012100 10800 3600
               604800 300 )
          NS   @
          A    2001:728:1808:5::6
$TTL 1
invalid   DNAME invalid6.rootcanary.net.
```

```
$ORIGIN invalid6.rootcanary.net
$TTL 300
@         SOA  invalid6.rootcanary.net. (
               sysadm.rootcanary.org.
               2020012100 10800 3600
               604800 300 )
          NS   @
          A    2001:7fb:fd04::6
*         A    2001:610:188:408::20
```

prefix	2001:728:1808::/48
max len	64
ASN	15562

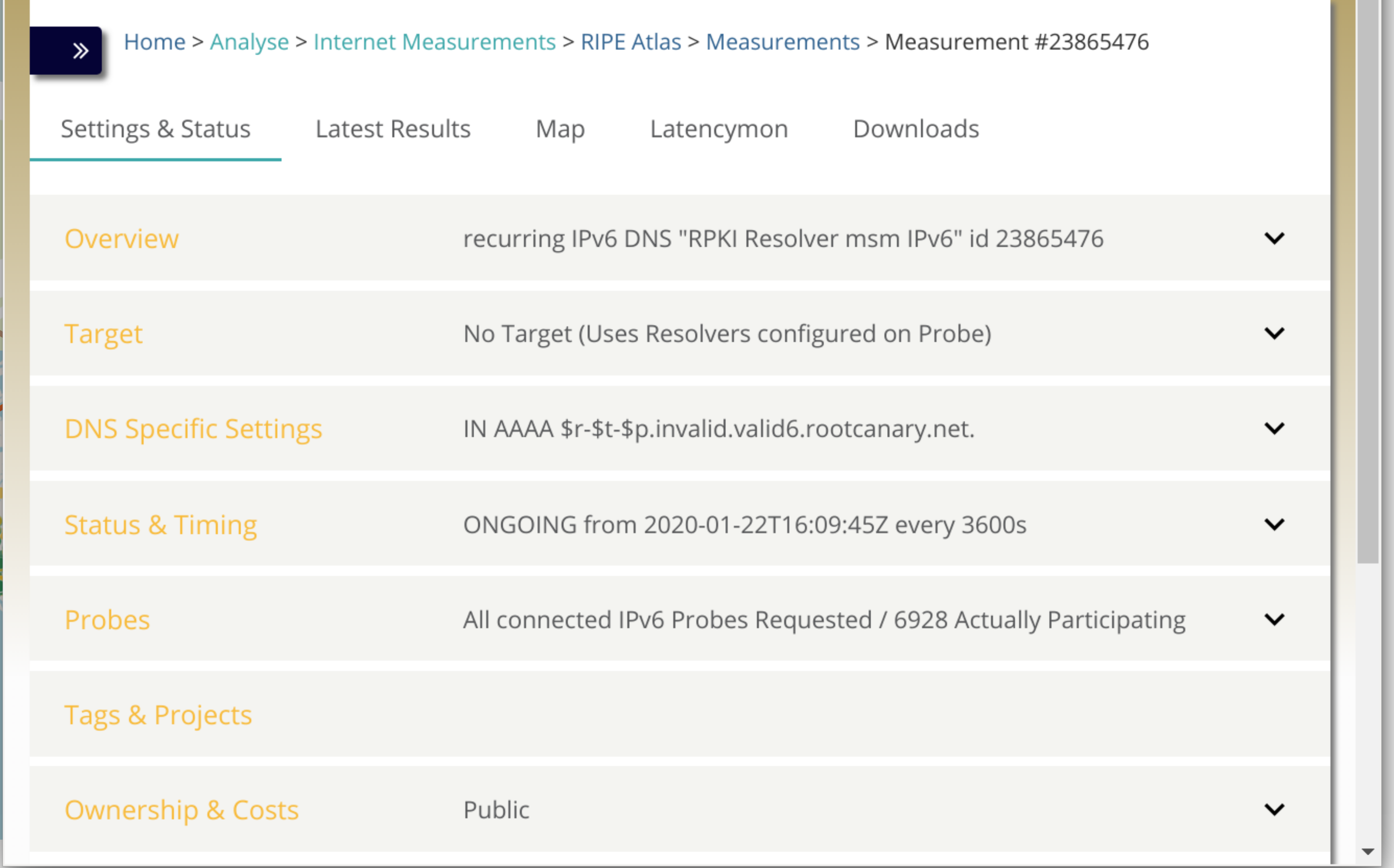
ROA

VALID

prefix	2001:7fb:fd04::/48
max len	48
ASN	196615

ROA

INVALID



Home > Analyse > Internet Measurements > RIPE Atlas > Measurements > Measurement #23865476

Overview recurring IPv6 DNS "RPKI Resolver msm IPv6" id 23865476

Target No Target (Uses Resolvers configured on Probe)

DNS Specific Settings IN AAAA $r-$t-$p.invalid.valid6.rootcanary.net.

Status & Timing ONGOING from 2020-01-22T16:09:45Z every 3600s

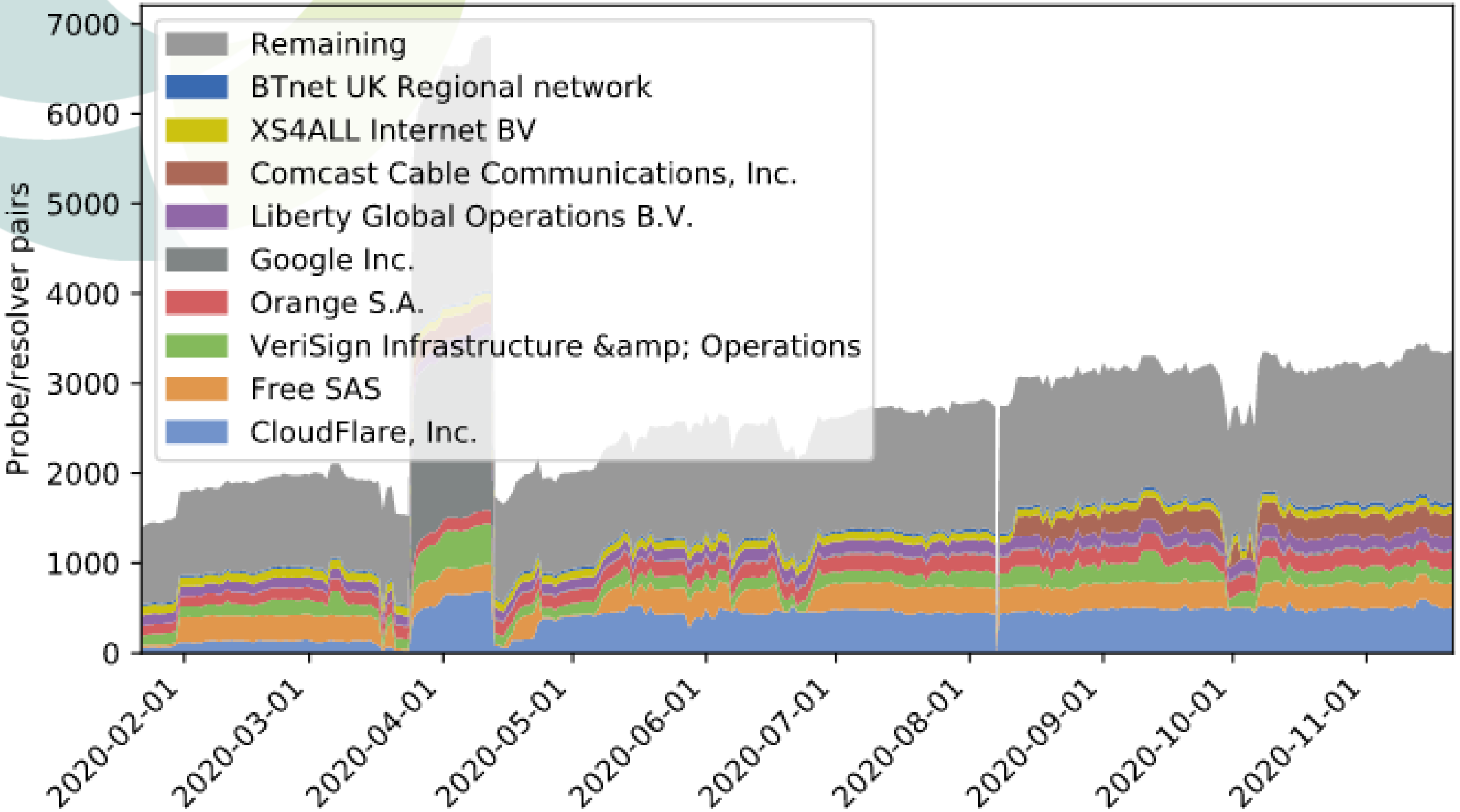
Probes All connected IPv6 Probes Requested / 6928 Actually Participating

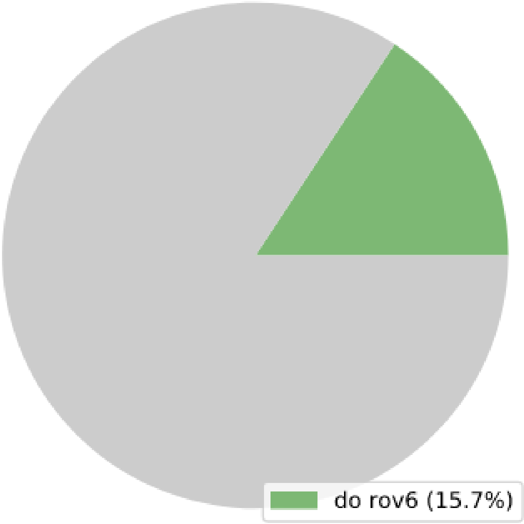
Tags & Projects

Ownership & Costs Public

DNSThought

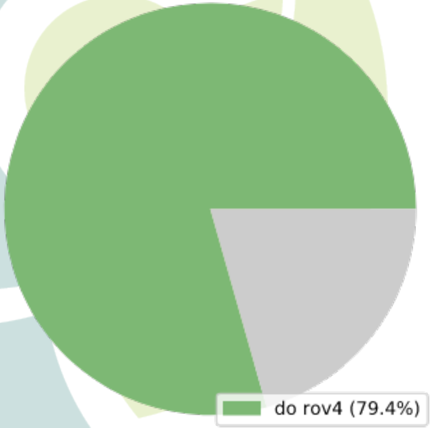
https://dnsthought.nlnetlabs.nl/does_rov6/#top_auth_asns



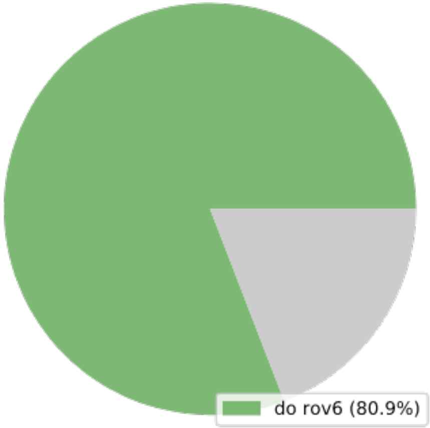


DNSThought

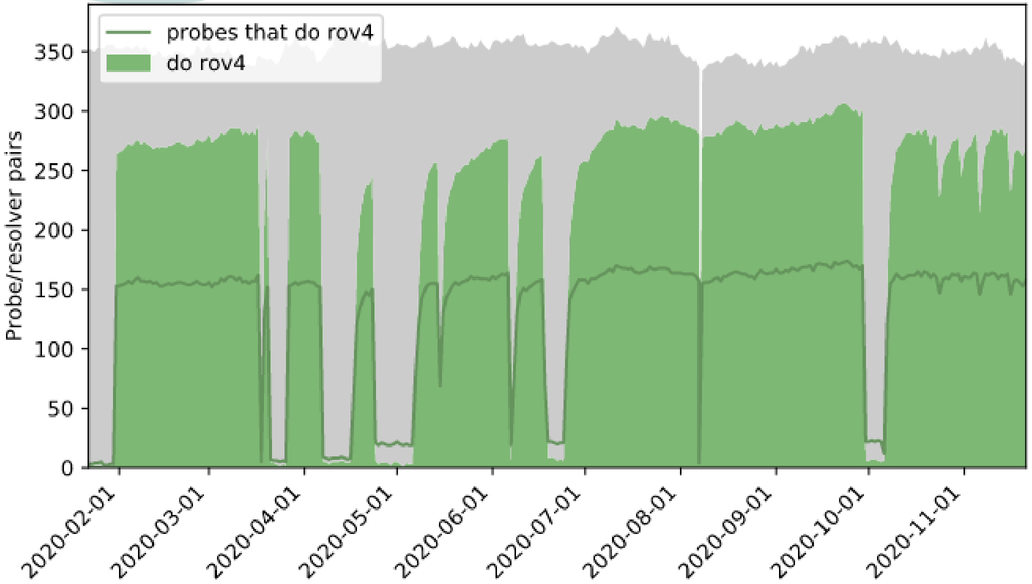
AS12322
Free SAS

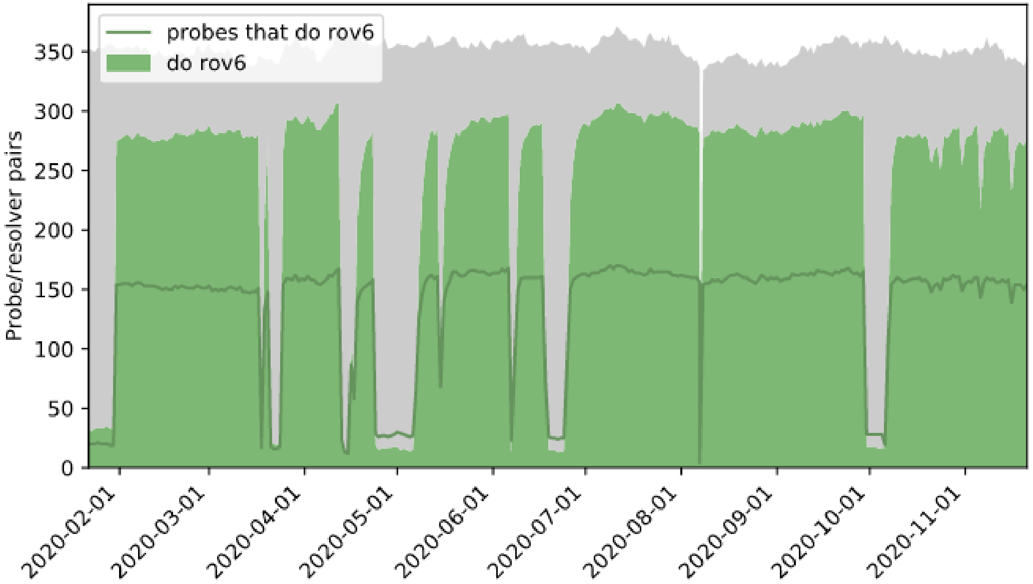


IPv4



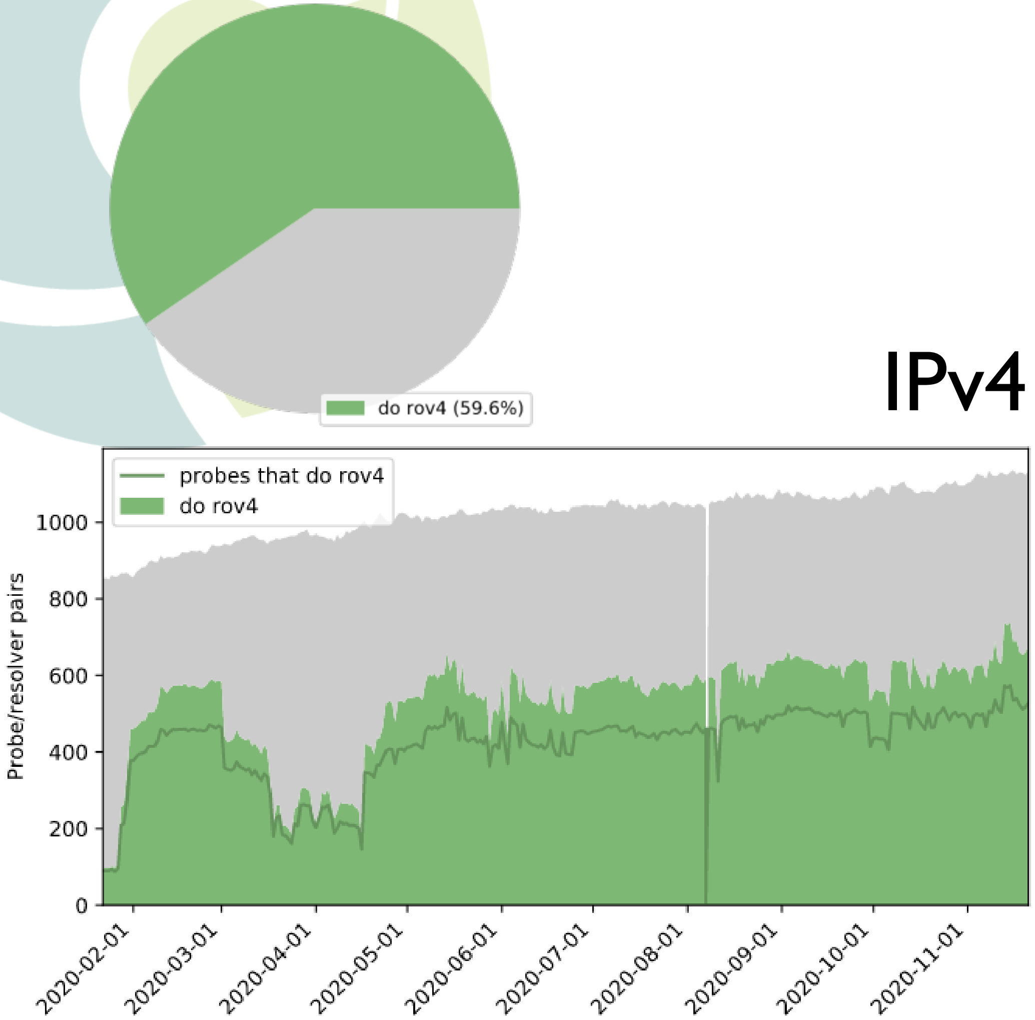
IPv6



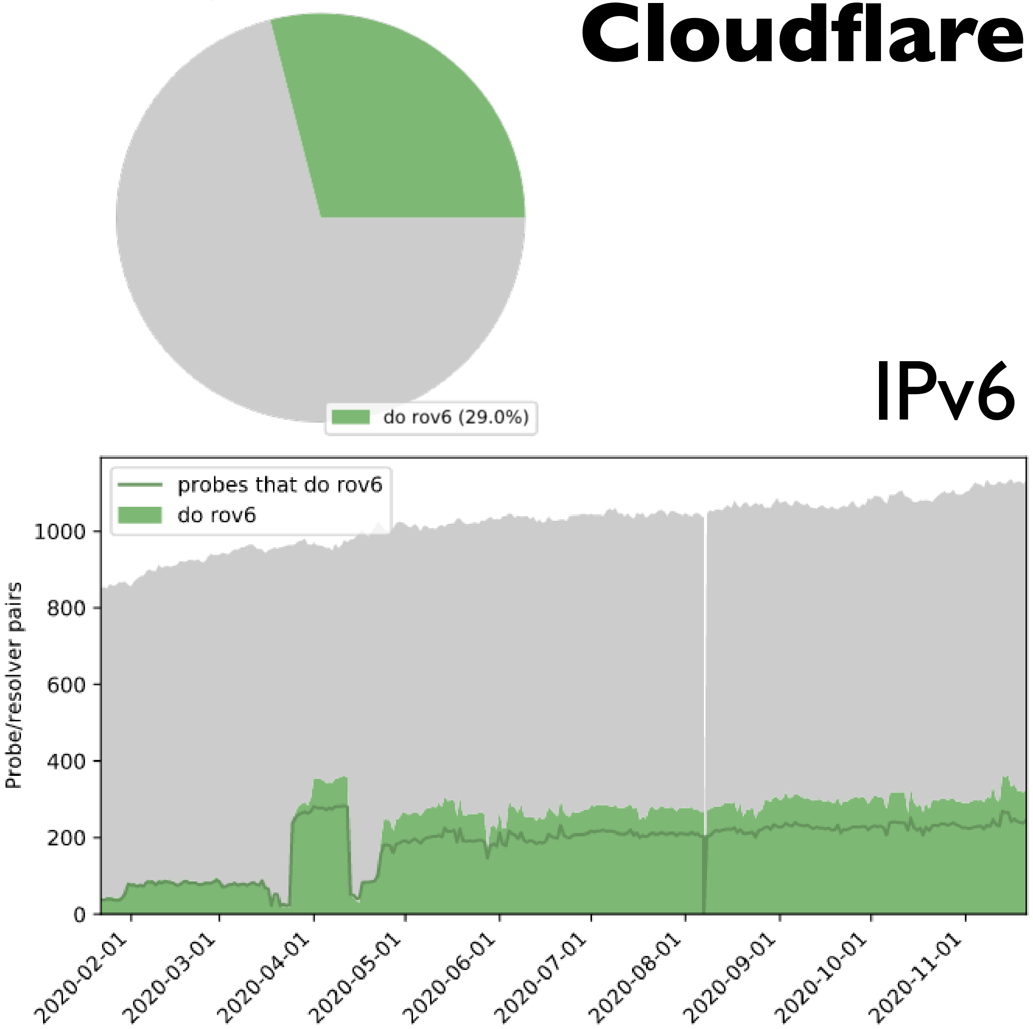


DNSThought

AS13335 Cloudflare



IPv4

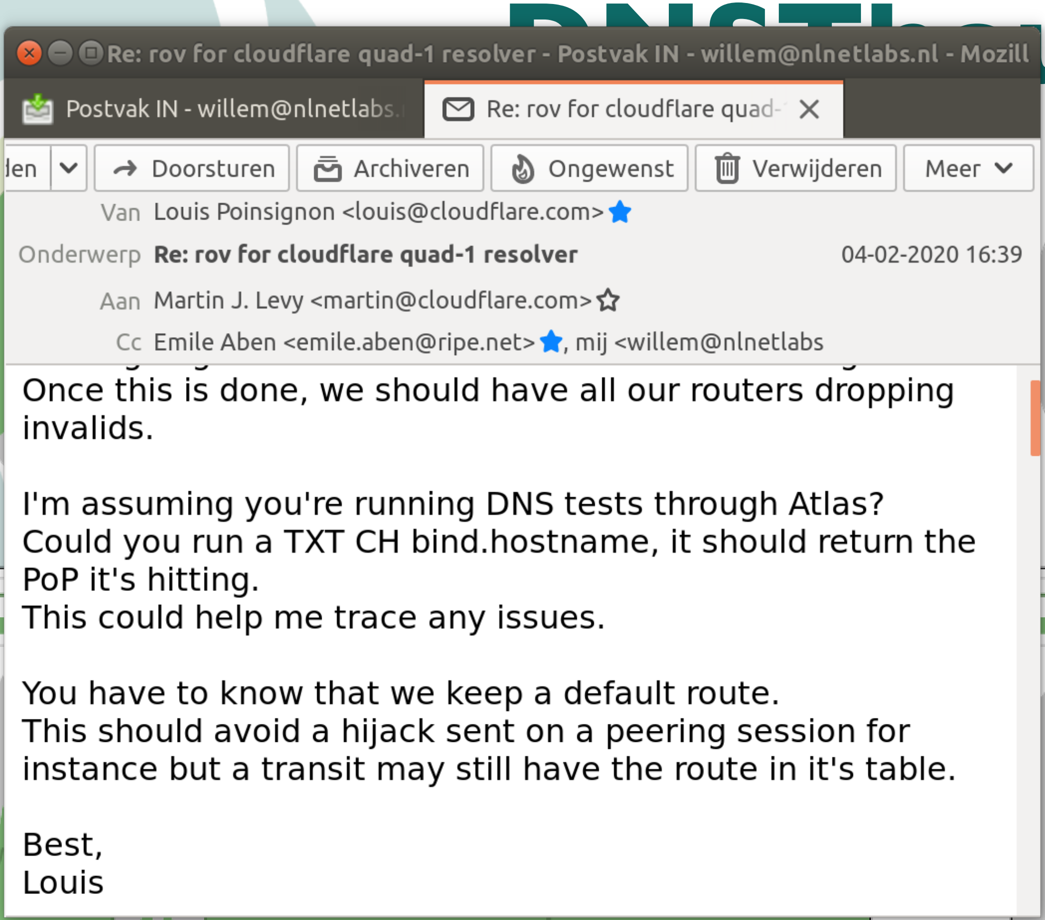


IPv6

DNSThought

AS13335 Cloudflare

IPv6


Re: rov for cloudflare quad-1 resolver - Postvak IN - willem@nlnetlabs.nl - Mozill
Postvak IN - willem@nlnetlabs.
Re: rov for cloudflare quad-
len
Doorsturen
Archiveren
Ongewenst
Verwijderen
Meer

Van Louis Poinsignon <louis@cloudflare.com>

Onderwerp **Re: rov for cloudflare quad-1 resolver** 04-02-2020 16:39

Aan Martin J. Levy <martin@cloudflare.com>

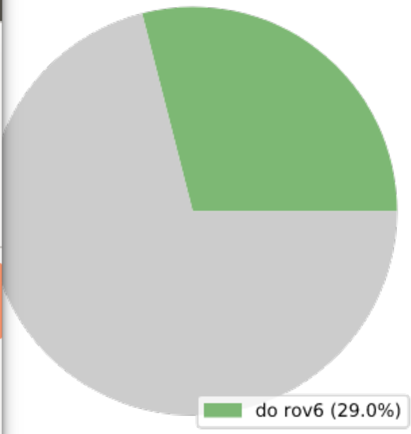
Cc Emile Aben <emile.aben@ripe.net>, mij <willem@nlnetlabs

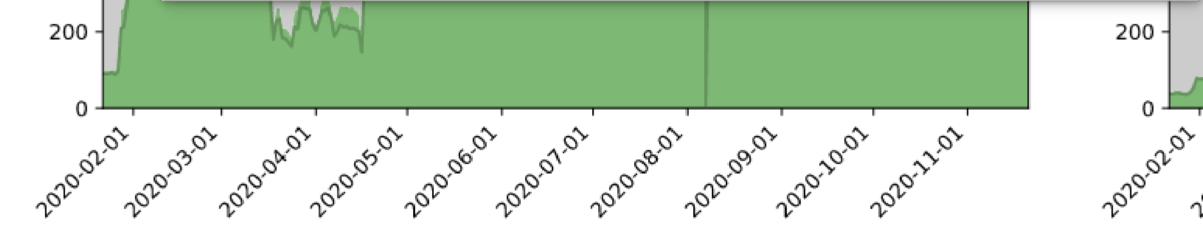
Once this is done, we should have all our routers dropping invalids.

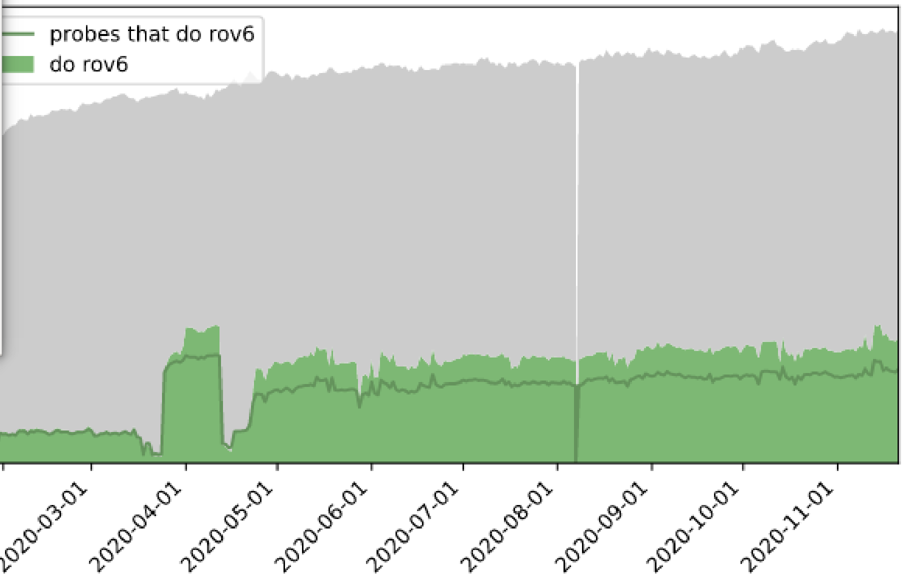
I'm assuming you're running DNS tests through Atlas?
Could you run a TXT CH bind.hostname, it should return the PoP it's hitting.
This could help me trace any issues.

You have to know that we keep a default route.
This should avoid a hijack sent on a peering session for instance but a transit may still have the route in it's table.

Best,
Louis



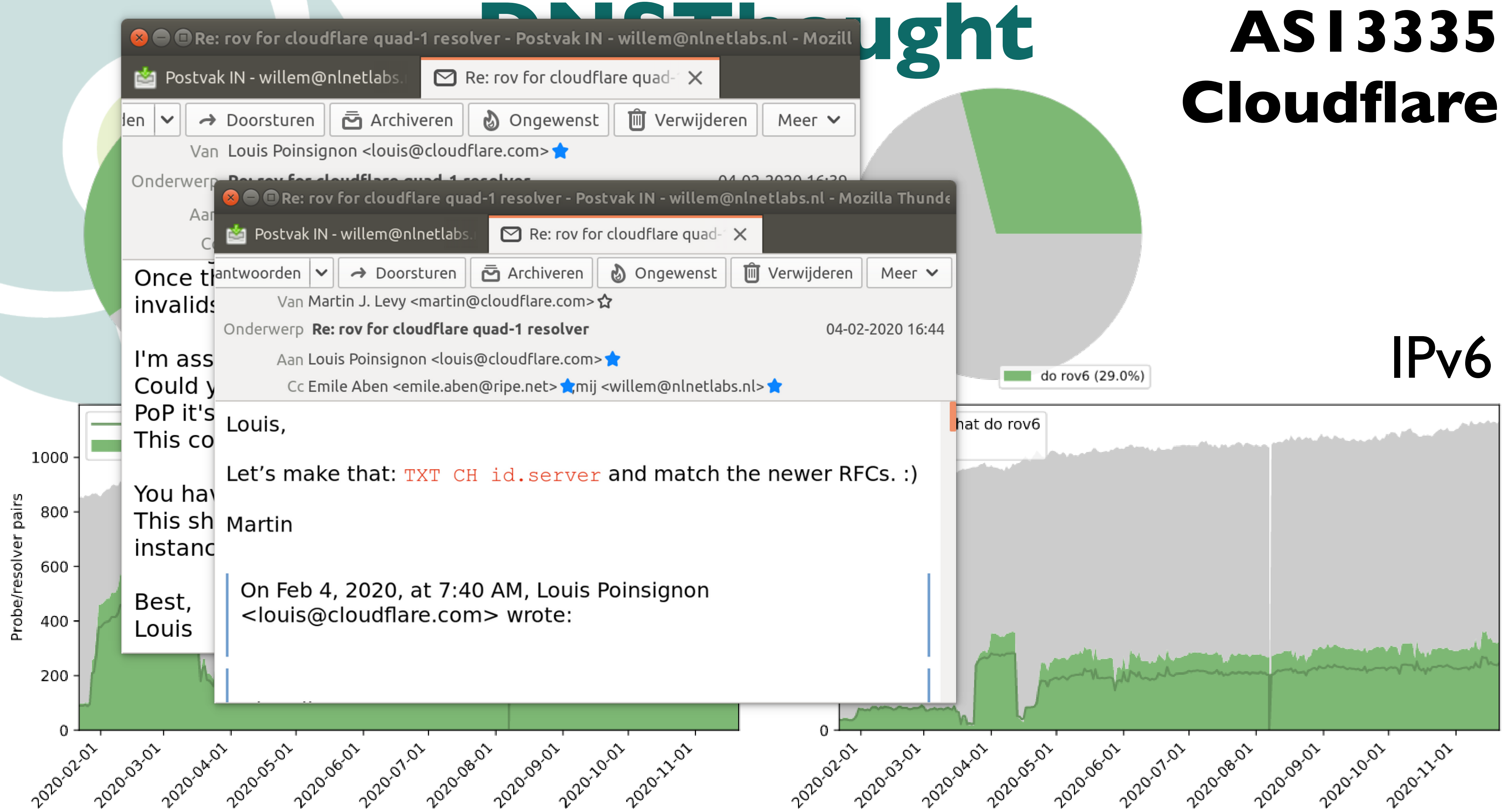




DNSThought

AS13335 Cloudflare

IPv6



Re: rov for cloudflare quad-1 resolver - Postvak IN - willem@nlnetlabs.nl - Mozill

Van Louis Poinsignon <louis@cloudflare.com>

Onderwerp Re: rov for cloudflare quad-1 resolver 04-02-2020 16:39

Once t
invalids

I'm ass
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PoP it's
This co

You hav
This sh
instanc

Best,
Louis

Re: rov for cloudflare quad-1 resolver - Postvak IN - willem@nlnetlabs.nl - Mozilla Thunde

Van Martin J. Levy <martin@cloudflare.com>

Onderwerp **Re: rov for cloudflare quad-1 resolver** 04-02-2020 16:44

Aan Louis Poinsignon <louis@cloudflare.com>

Cc Emile Aben <emile.aben@ripe.net>, mij <willem@nlnetlabs.nl>

Louis,

Let’s make that: `TXT CH id.server` and match the newer RFCs. :)

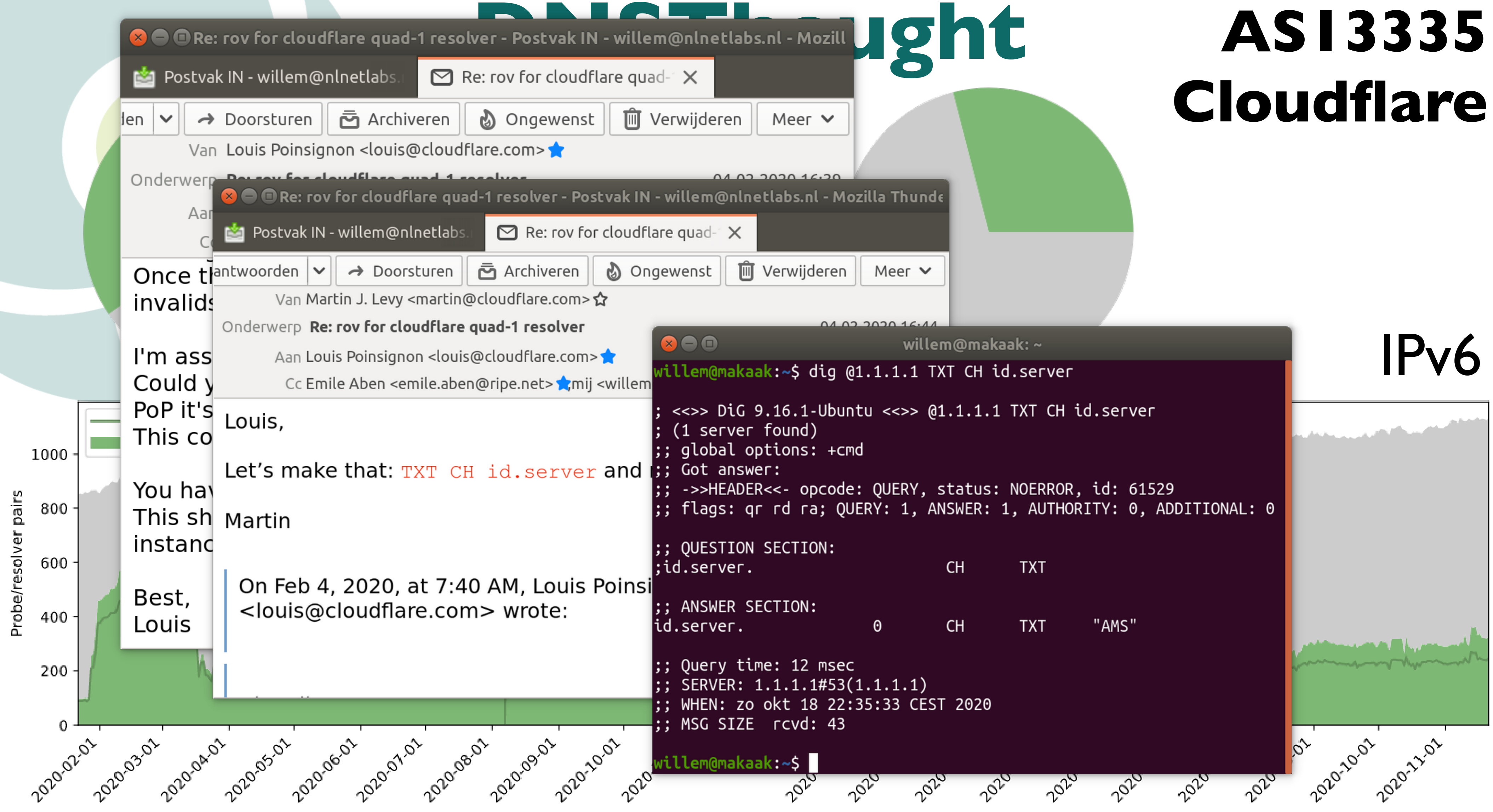
Martin

> On Feb 4, 2020, at 7:40 AM, Louis Poinsignon <louis@cloudflare.com> wrote:

DNSThought

AS13335 Cloudflare

IPv6


Re: rov for cloudflare quad-1 resolver - Postvak IN - willem@nlnetlabs.nl - Mozill
Postvak IN - willem@nlnetlabs.
Re: rov for cloudflare quad-
den
Doorsturen
Archiveren
Ongewenst
Verwijderen
Meer
Re: rov for cloudflare quad-1 resolver - Postvak IN - willem@nlnetlabs.nl - Mozilla Thunde
Postvak IN - willem@nlnetlabs.
Re: rov for cloudflare quad-
antwoorden
Doorsturen
Archiveren
Ongewenst
Verwijderen
Meer
willem@makaak: ~
Probe/resolver pairs
0
200
400
600
800
1000
2020-02-01
2020-03-01
2020-04-01
2020-05-01
2020-06-01
2020-07-01
2020-08-01
2020-09-01
2020-10-01
2020-10-01
2020-11-01

Van Louis Poinsignon <louis@cloudflare.com>

Onderwerp

Aan

Cc

Once t
invalids

I'm ass
Could y
PoP it's
This co

You hav
This sh
instanc

Best,
Louis

Van Martin J. Levy <martin@cloudflare.com>

Onderwerp **Re: rov for cloudflare quad-1 resolver**

Aan Louis Poinsignon <louis@cloudflare.com>

Cc Emile Aben <emile.aben@ripe.net>, mij <willem

Louis,

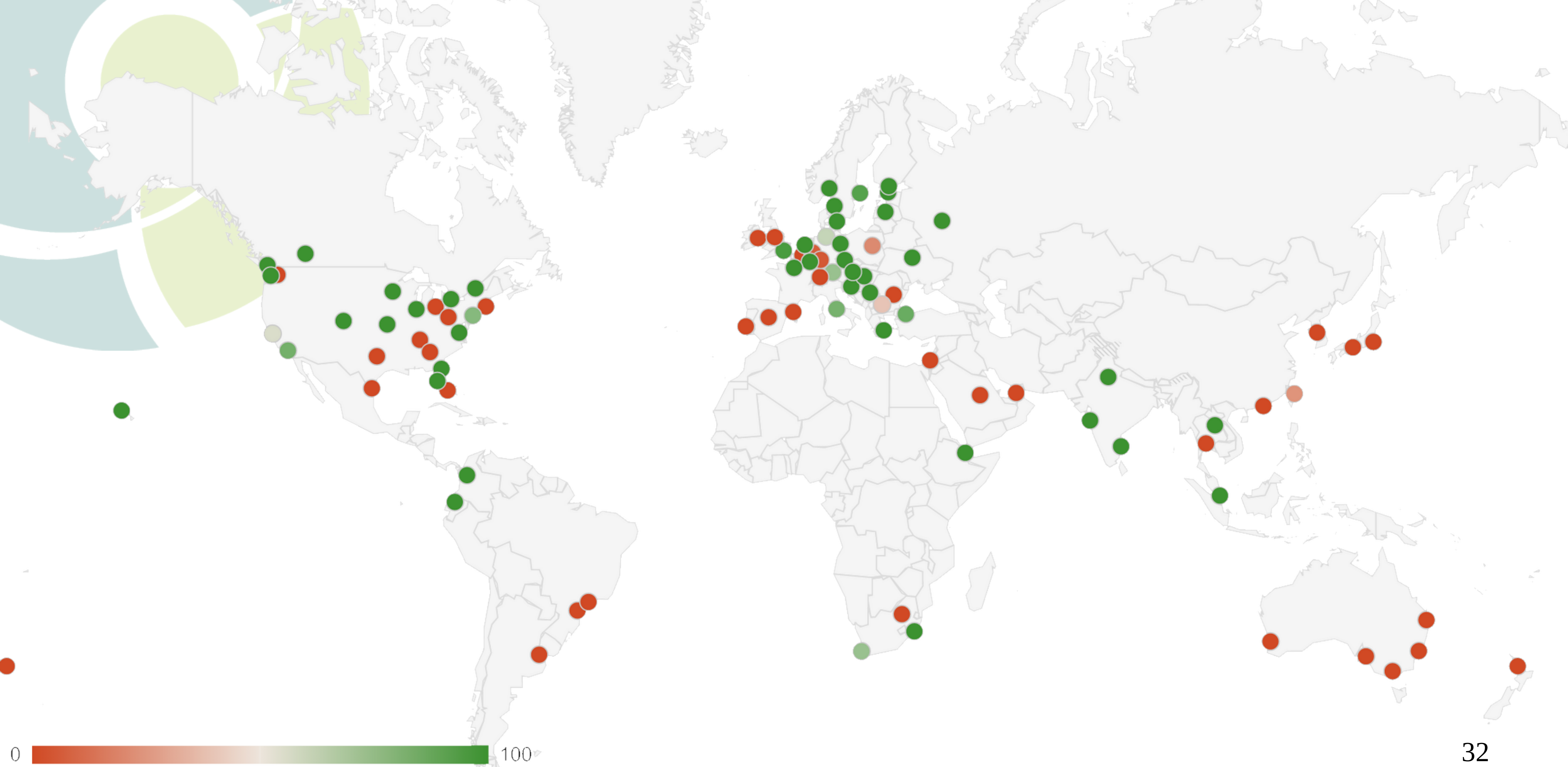
Let's make that: `TXT CH id.server` and

Martin

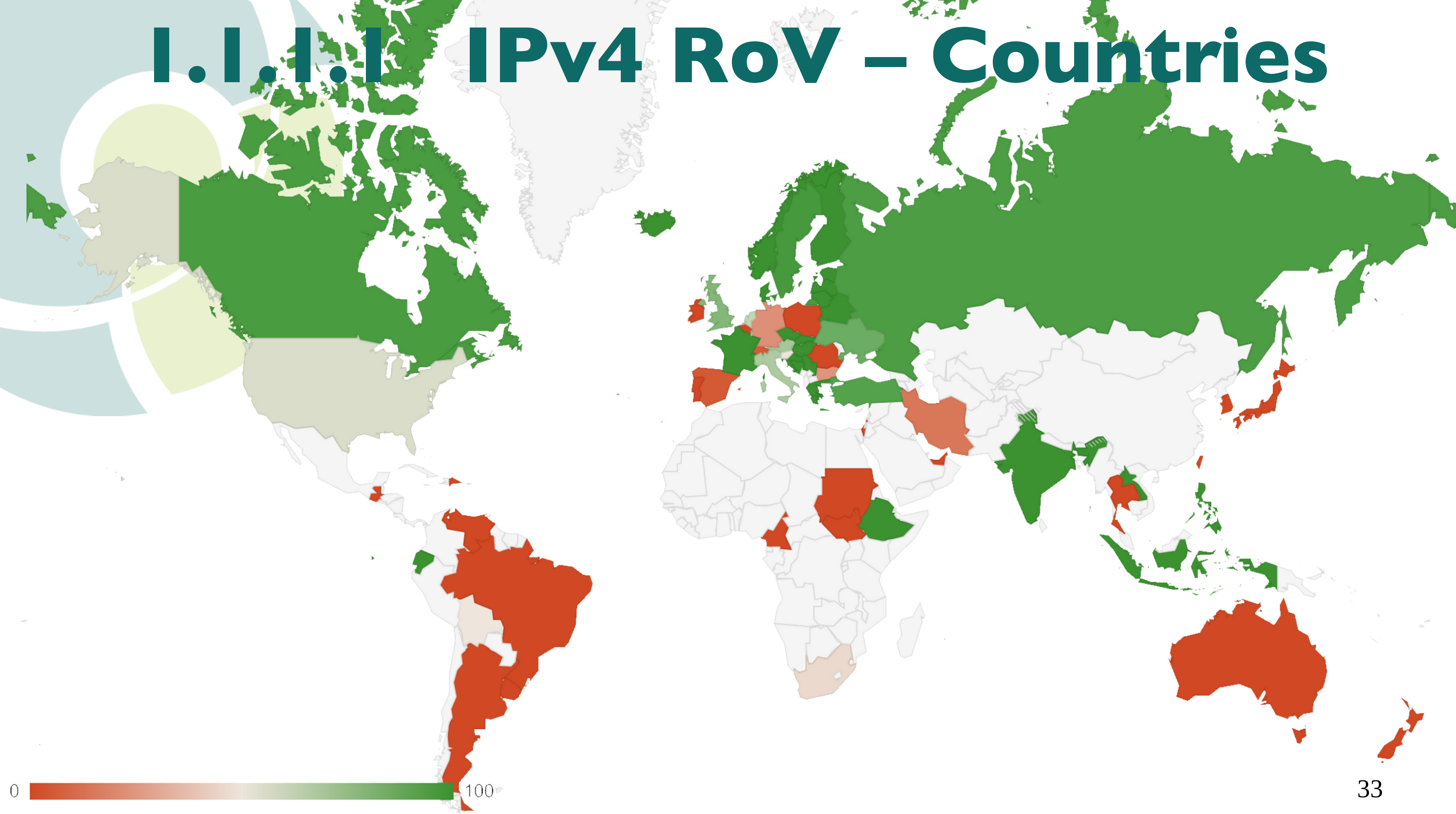
> On Feb 4, 2020, at 7:40 AM, Louis Poinsi
> <louis@cloudflare.com> wrote:

```
willem@makaak:~$ dig @1.1.1.1 TXT CH id.server

; <<>> DiG 9.16.1-Ubuntu <<>> @1.1.1.1 TXT CH id.server
; (1 server found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 61529
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 0

;; QUESTION SECTION:
;id.server.                     CH      TXT

;; ANSWER SECTION:
id.server.              0       CH      TXT     "AMS"

;; Query time: 12 msec
;; SERVER: 1.1.1.1#53(1.1.1.1)
;; WHEN: zo okt 18 22:35:33 CEST 2020
;; MSG SIZE  rcvd: 43

willem@makaak:~$
```

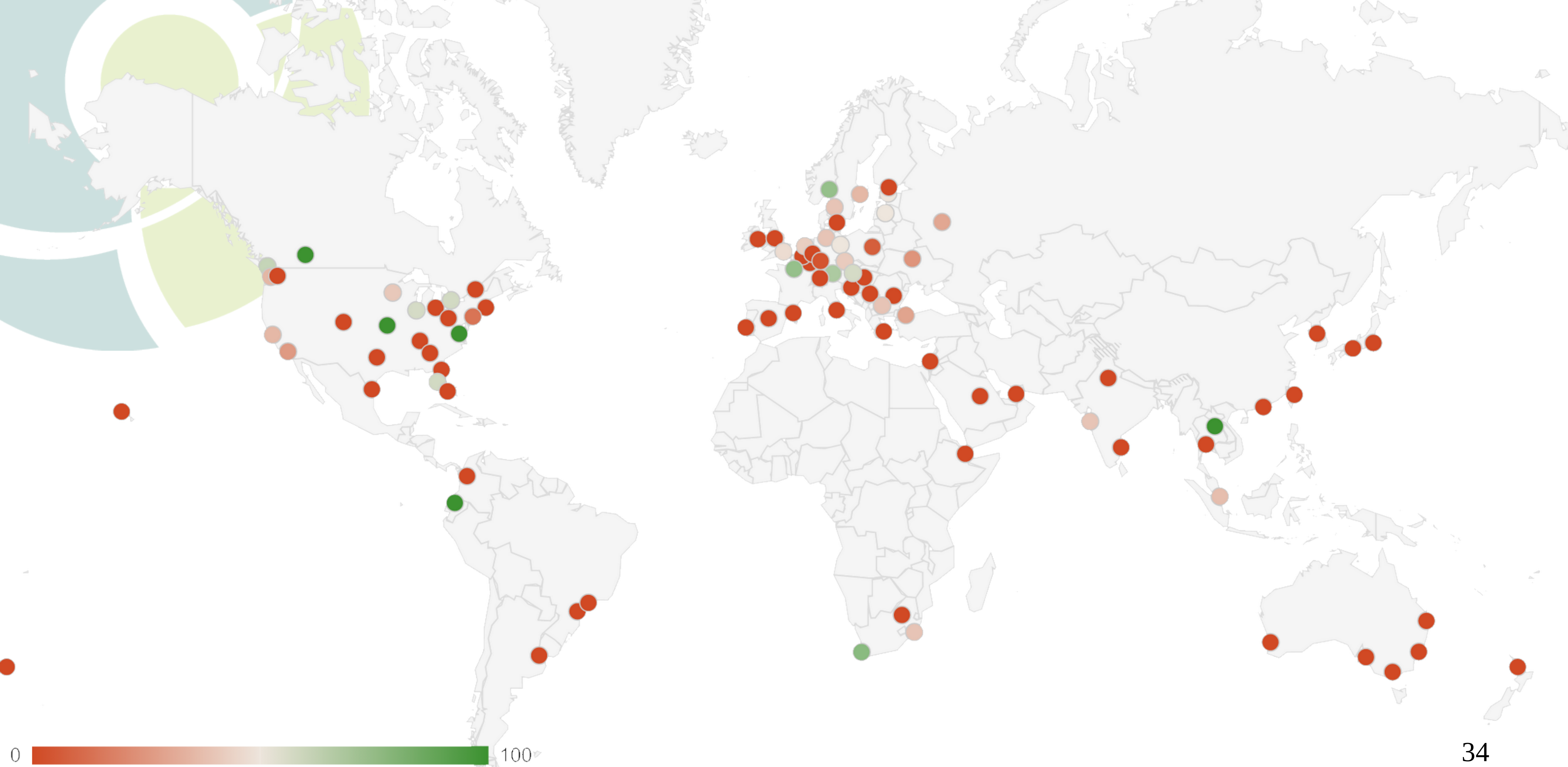
1.1.1.1 IPv4 RoV – PoPs



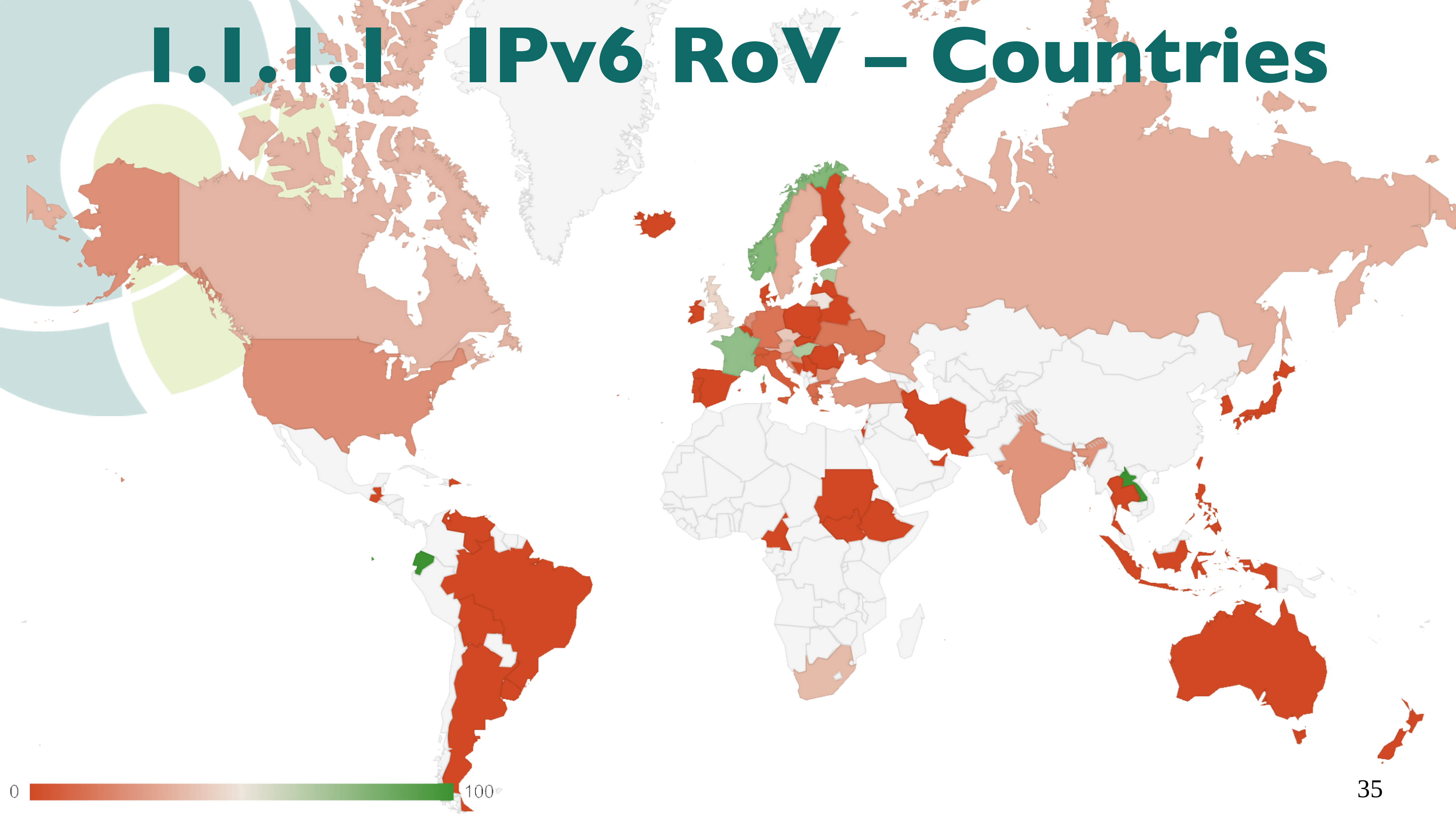
1.1.1.1 IPv4 RoV – Countries



1.1.1.1 IPv6 RoV – PoPs



1.1.1.1 IPv6 RoV – Countries



Future improvements

- We looked at authoritatives only
  - measurement network with **more vantage points**!
- Beacons all over the world
- dnsthought results for (probe, resolver, IP @ auth)
- dnsthought measurements for *not* answering auth to inventory IP @ auth for (probe, resolver)

Questions?

- Research performed by:
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- From
  - University of Amsterdam
- At
  - NLNETLABS
- On
  - January 2020
- Report:
  - https://delaat.net/rp/2019-2020/p04/report.pdf
- DNSThought:
  - https://dnsthought.nlnetlabs.nl/