

# IP Technology Adoption in Mongolia

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# Why?

- Mongolia has a really high rate of adoption of DNSSEC in their recursive resolvers
- And a pretty good rate of RoV ROA filtering for routing security
- And a close to perfect rate of signed ROAs

# Why?

- Mongolia has a really high rate of adoption of DNSSEC in their recursive resolvers
- And a pretty good rate of RoV ROA filtering for routing security
- And a close to perfect rate of signed ROAs

Yet ...

- No IPv6!

# Mongolia is not that unusual

Many national environments have a unique technology adoption profile across these 4 technologies:

|                 | <b>DNSSEC</b> | <b>IPv6</b> | <b>ROA Signing</b> | <b>RoV Filtering</b> |
|-----------------|---------------|-------------|--------------------|----------------------|
| <b>Bhutan</b>   | high          | not much    | perfect            | decent               |
| <b>Sweden</b>   | high          | not much    | not really         | good                 |
| <b>Brazil</b>   | high          | decent      | nope               | none                 |
| <b>Spain</b>    | low           | not much    | decent             | none                 |
| <b>India</b>    | high          | huge        | decent             | not much             |
| <b>US</b>       | so-so         | good        | decent             | so-so                |
| <b>Mongolia</b> | <b>high</b>   | <b>nope</b> | <b>perfect!</b>    | <b>good</b>          |

# Sameness and Differences

- All these markets have a similar technology base for consumers
- And they all use equipment drawn from a similar pool of vendors
- And the supply costs are largely the same across the entire network

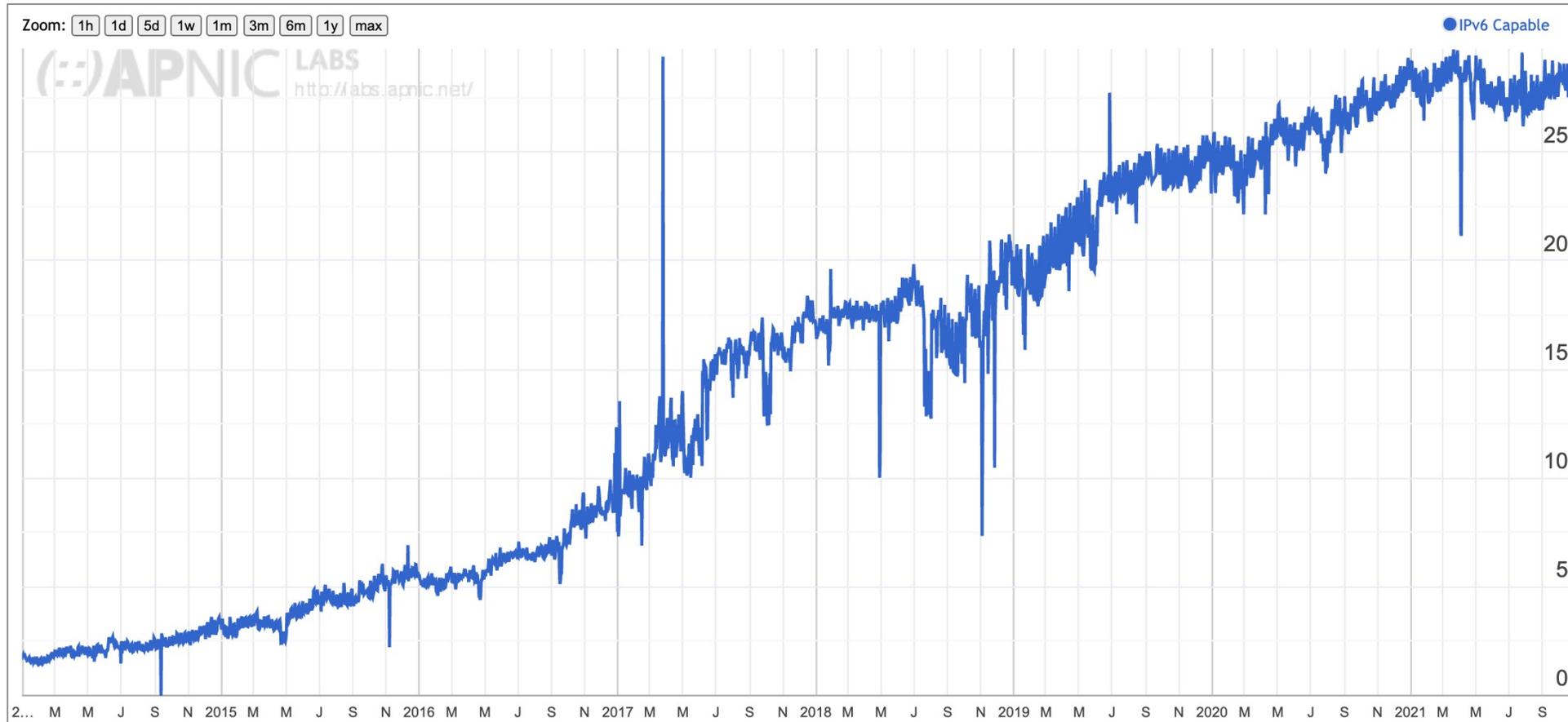
Yet

- They have different consumer “wealth” indicators
- There are different technology deployment models in each national market
- Though relative wealth and technology choices do not correlate well!

Lets look at each technology  
in a little more detail

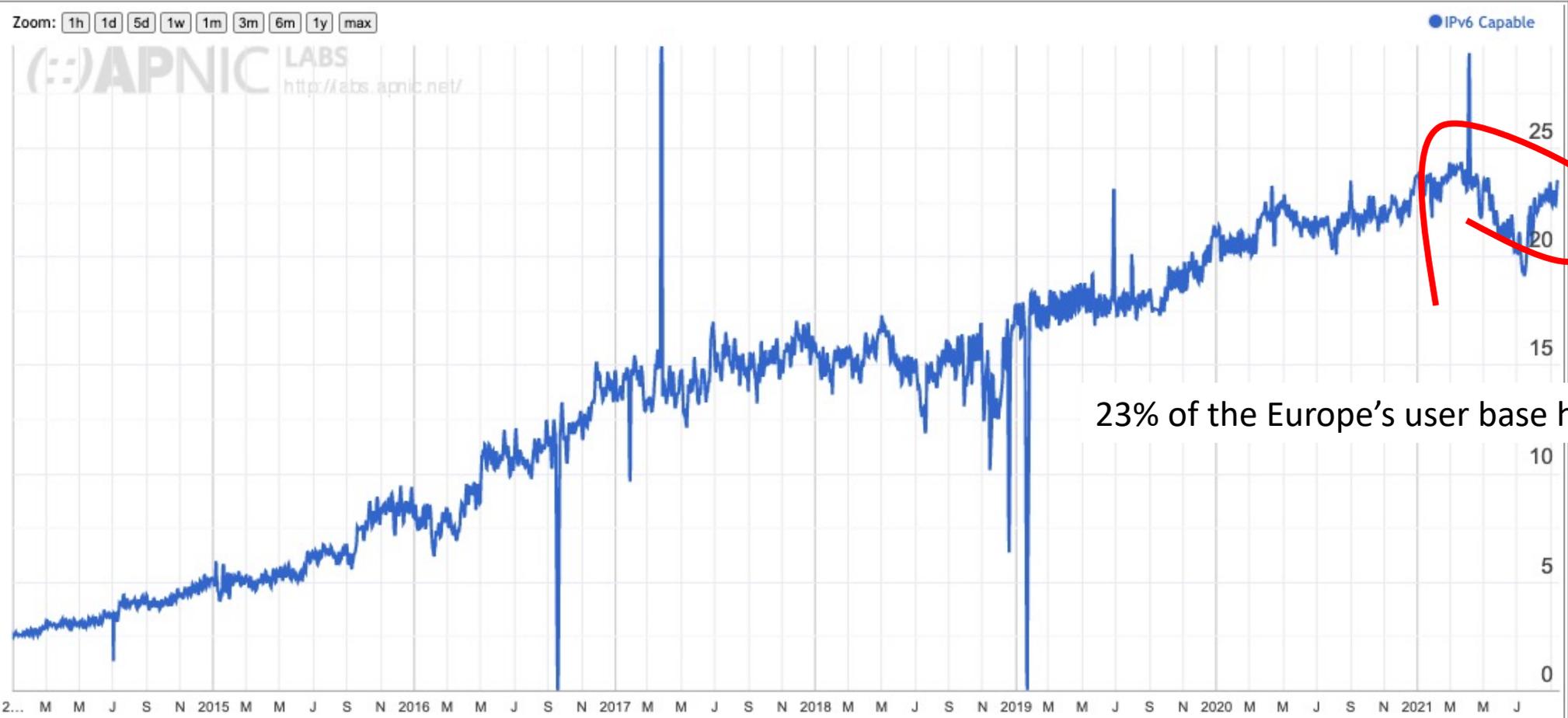
# I. IPv6 Adoption

# Internet IPv6 Adoption 2014 to Today



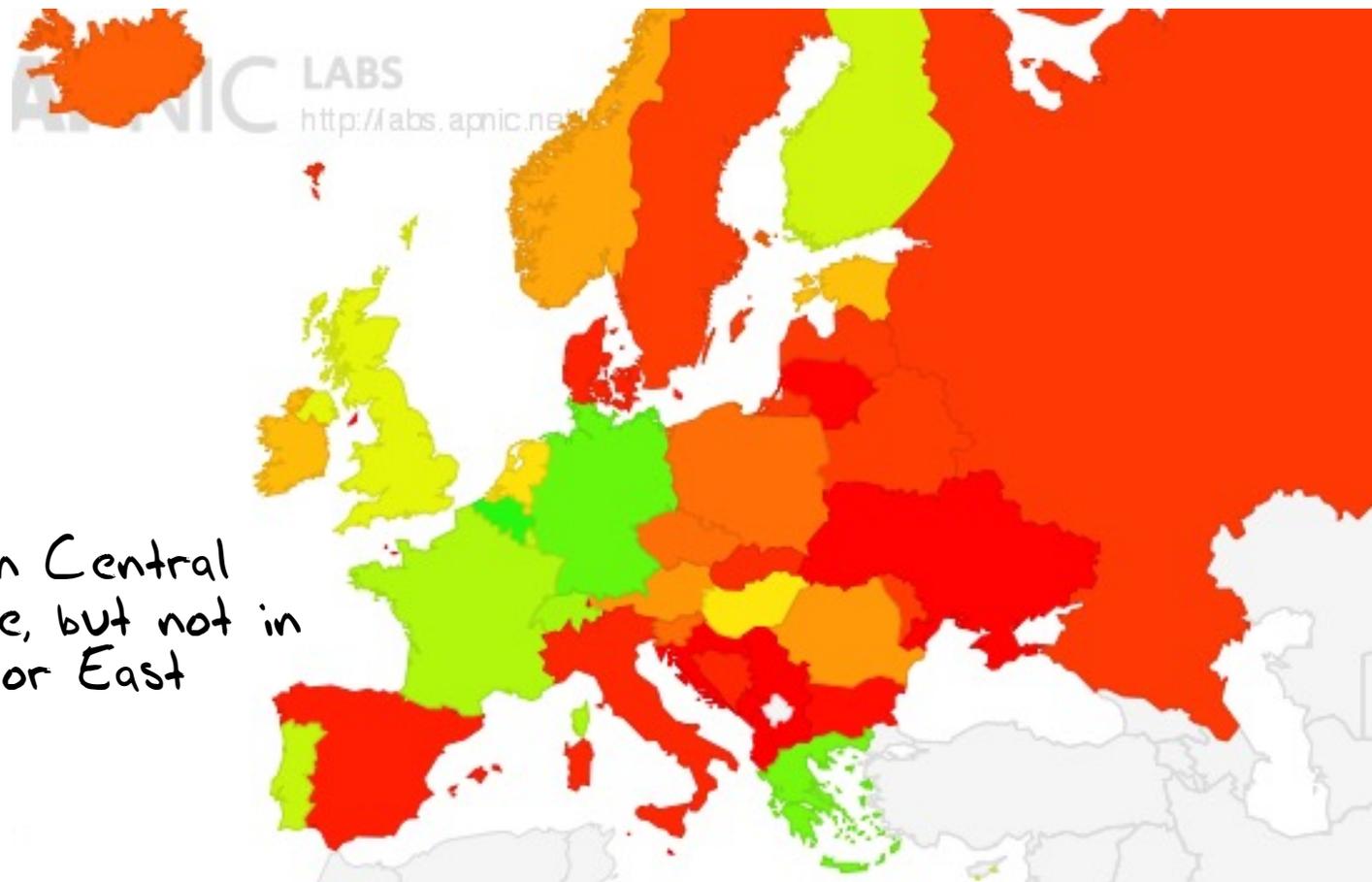
28% of the Internet's  
user base have IPv6  
today

# Europe is (slightly) lagging...



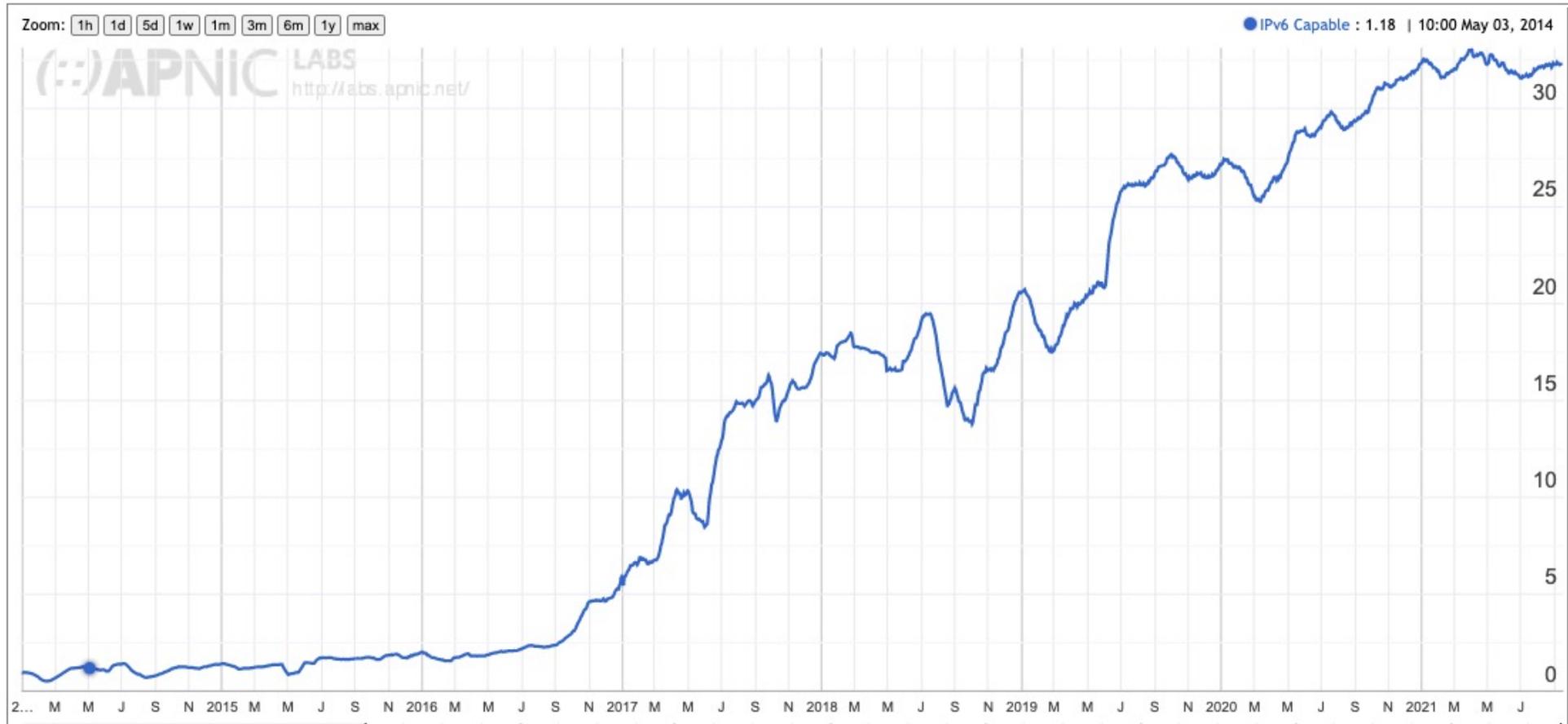
23% of the Europe's user base have IPv6 today

# And is very diverse

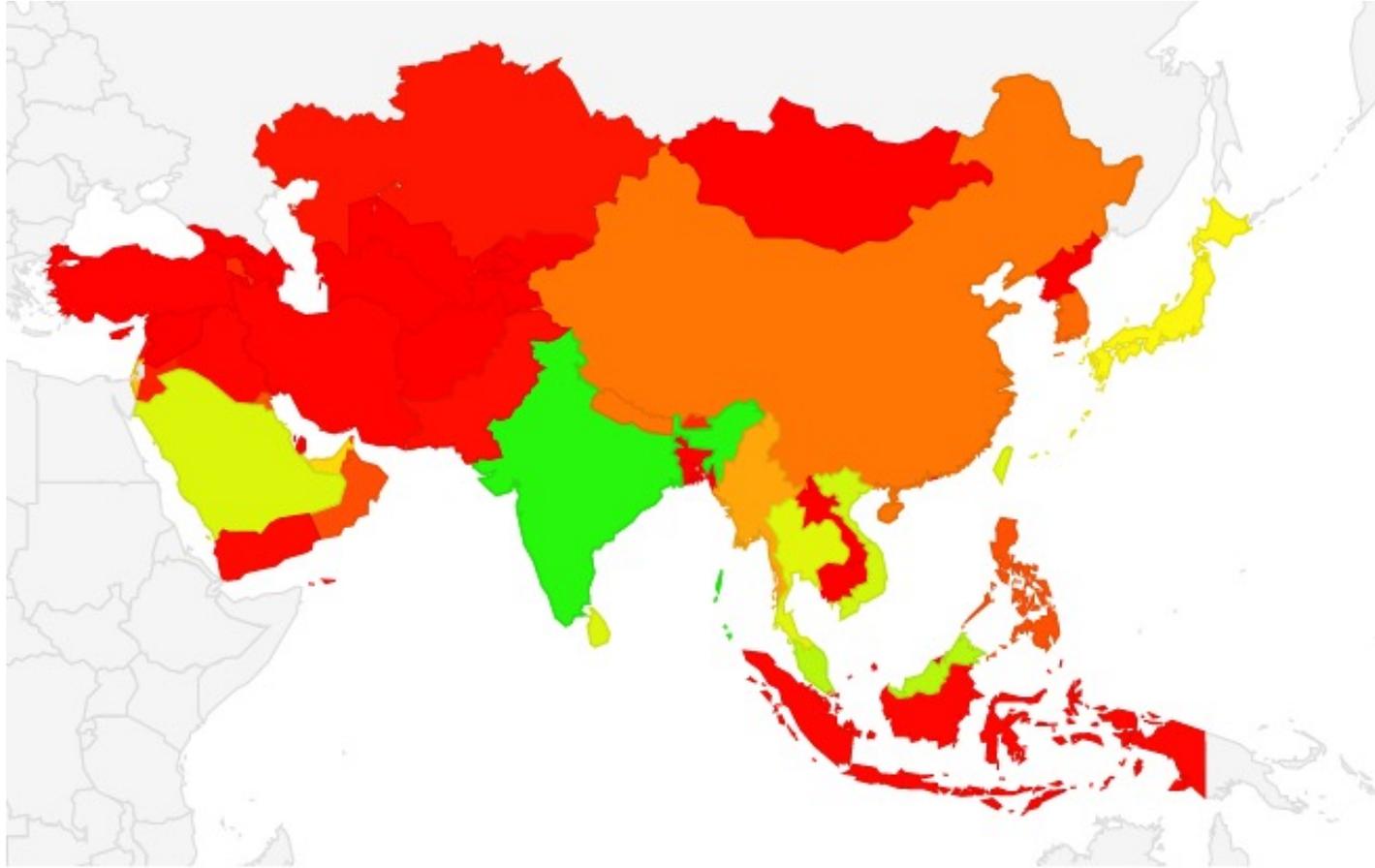


IPv6 is deployed in Central Europe and Greece, but not in the North, South or East

# Asia has better numbers

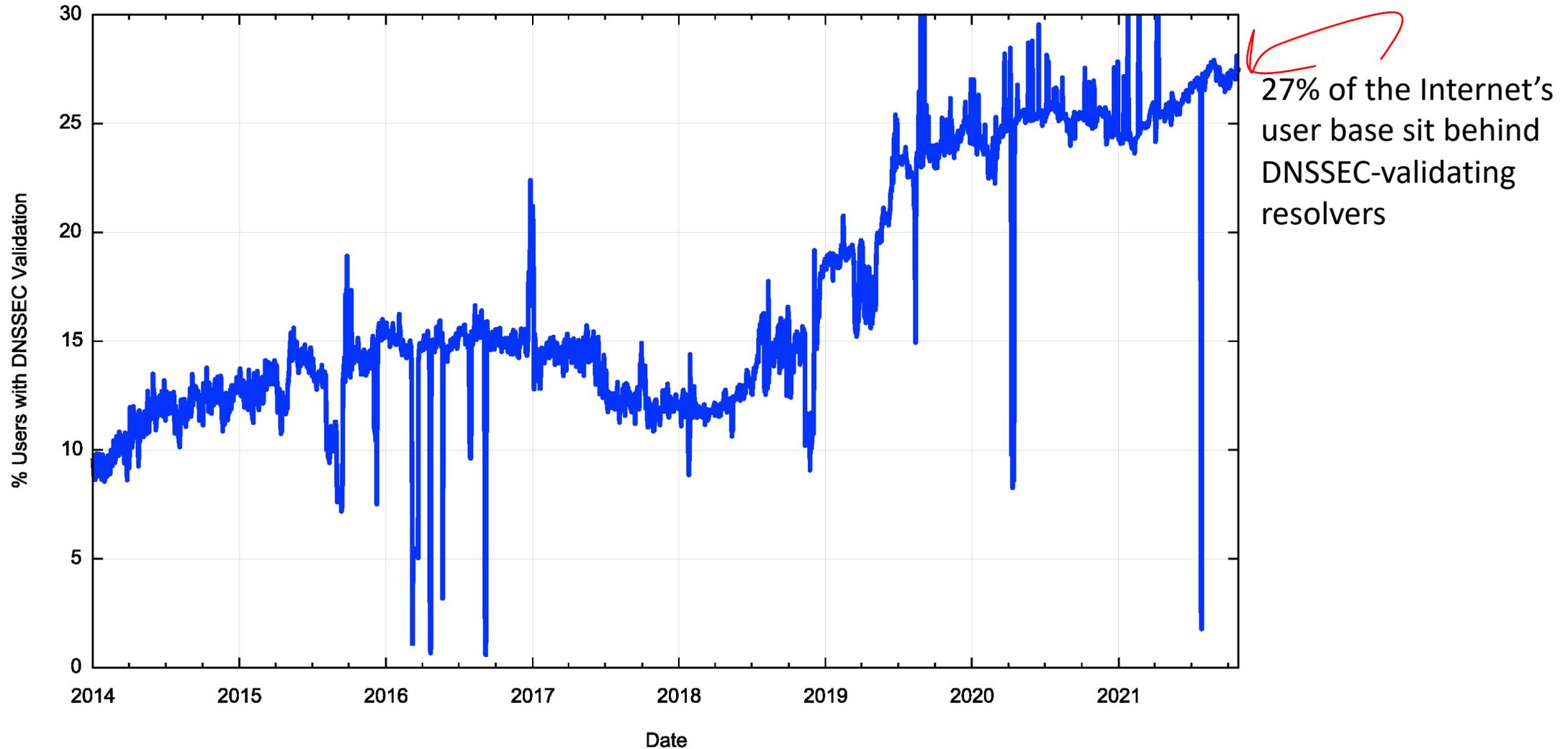


And similar diversity

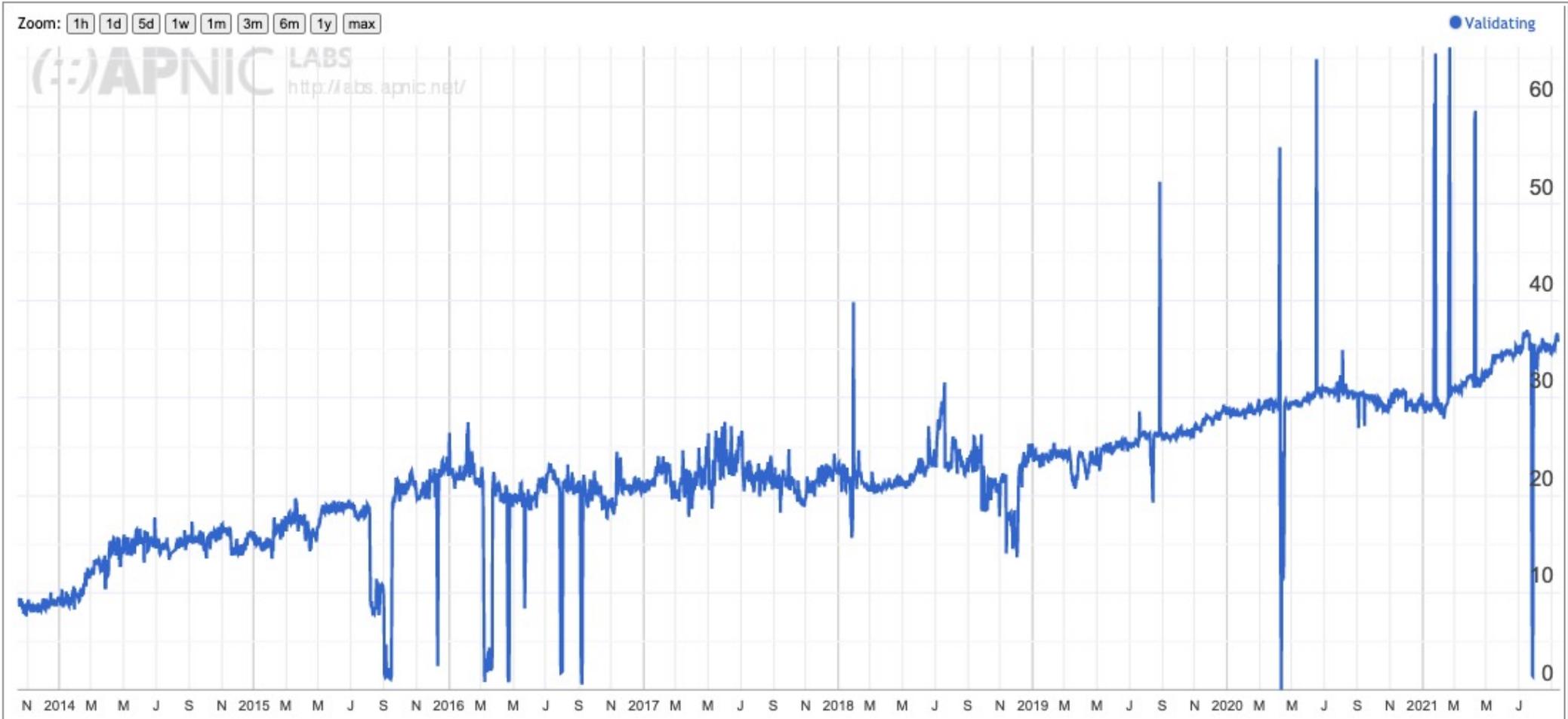


## II. DNSSEC Adoption

# DNSSEC Adoption Internet-wide Validation Count

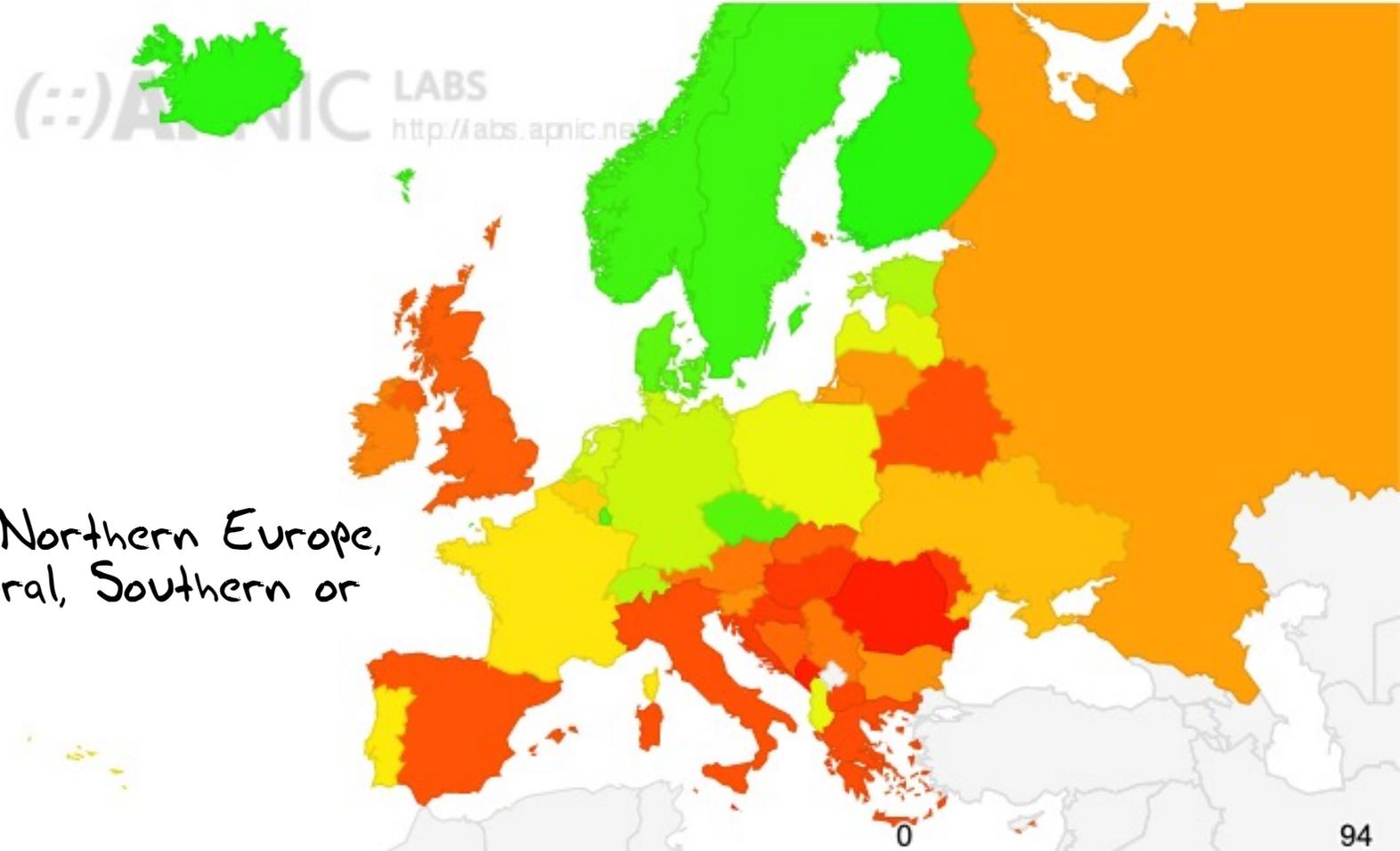


# Europe is (slightly) ahead

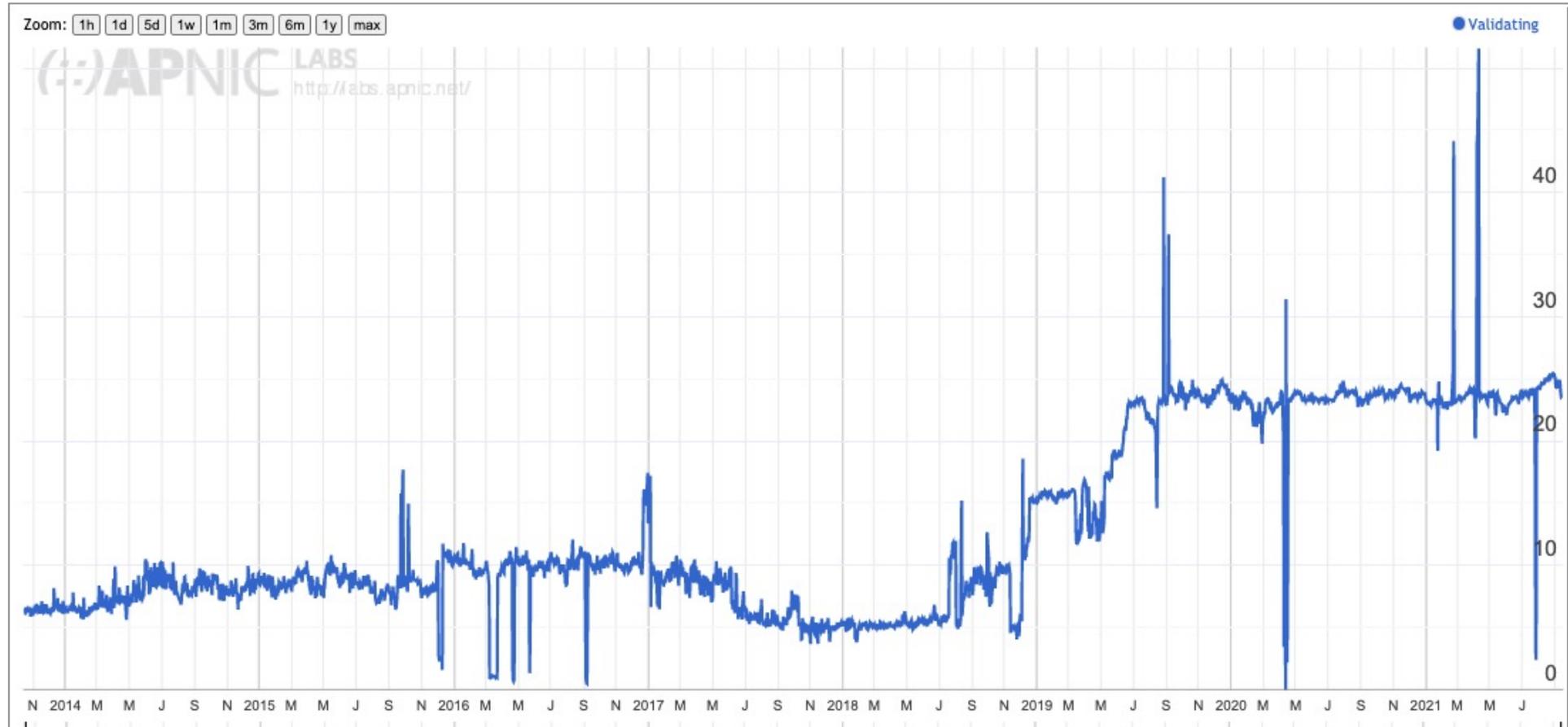


# Same (but different) diversity

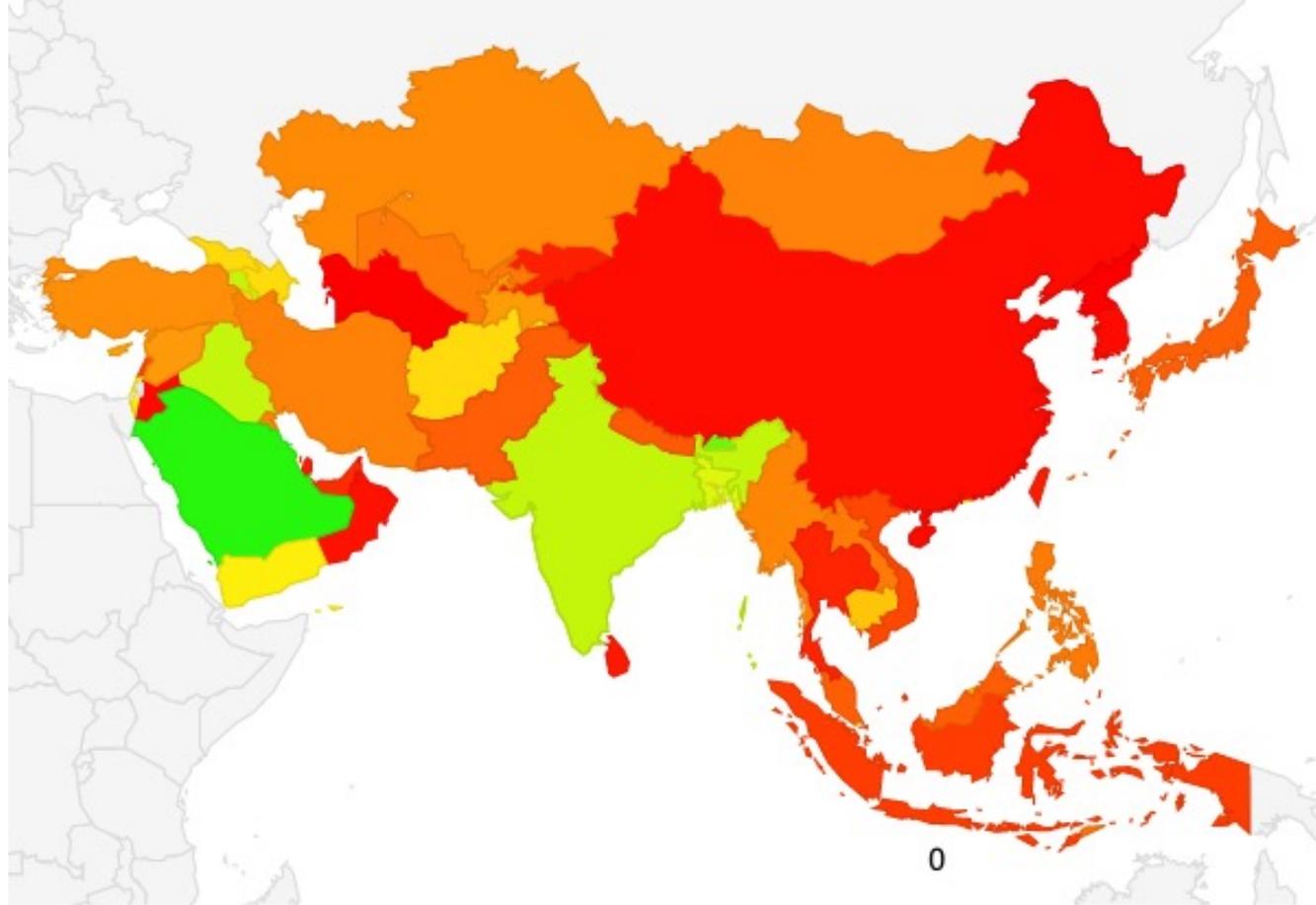
DNSSEC is deployed in Northern Europe, but not as much in Central, Southern or Eastern Europe



# Asia has been steady for 24 months



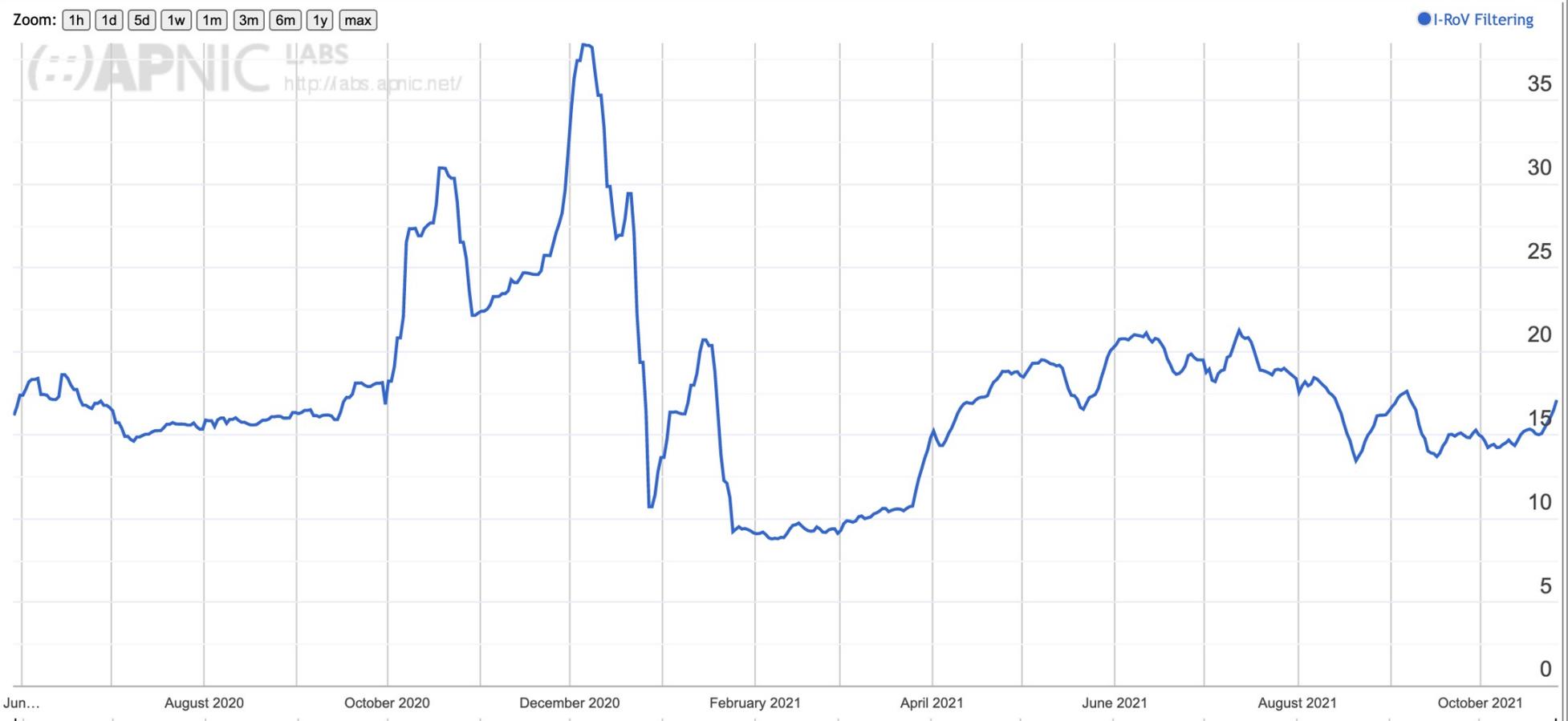
And again a diverse (but different) spread



# III. Routing Security

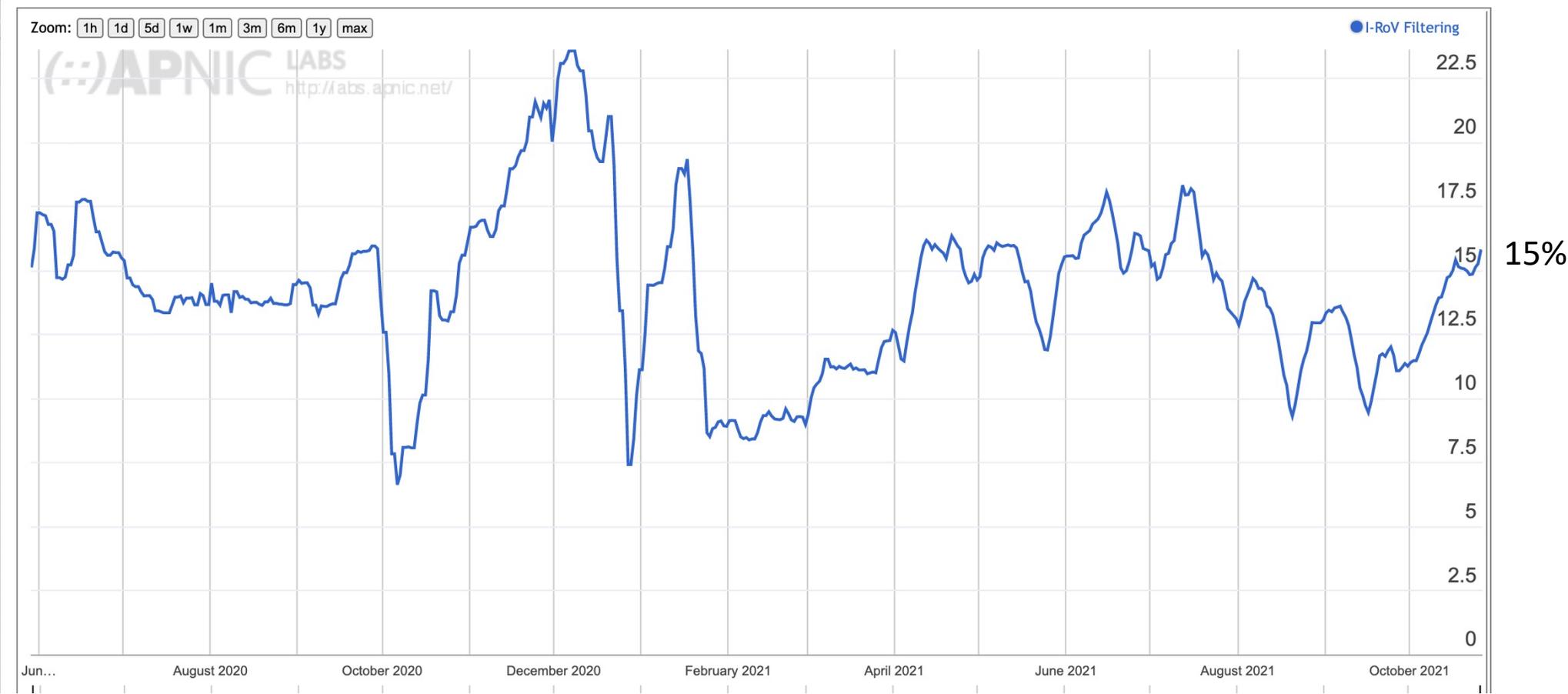
- Signing ROAs
- Validating routes against ROAs and Dropping Invalids (ROV)

# RPKI ROV Adoption



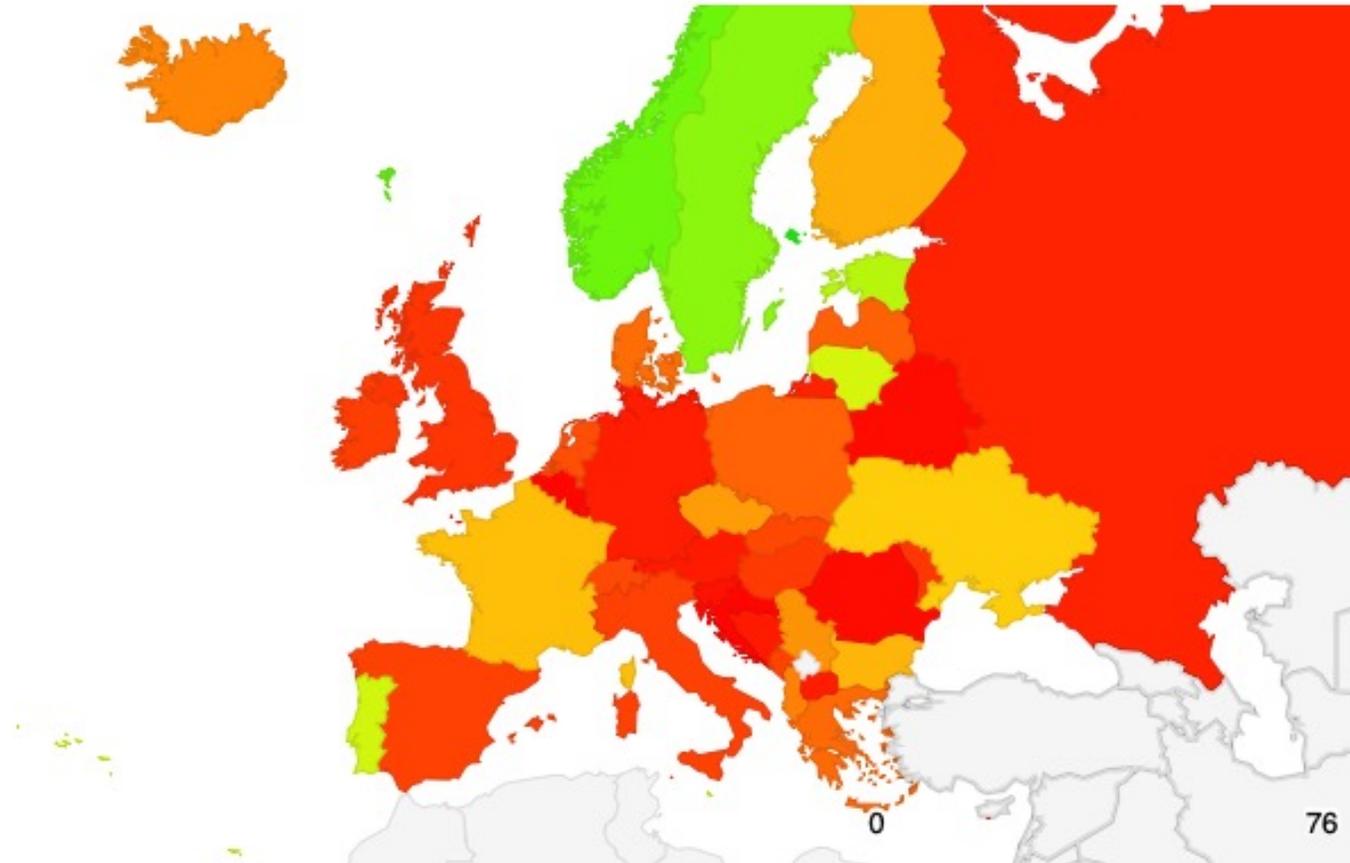
15% of users can't reach a destination if the route is RoV invalid

# RPKI ROV - Europe

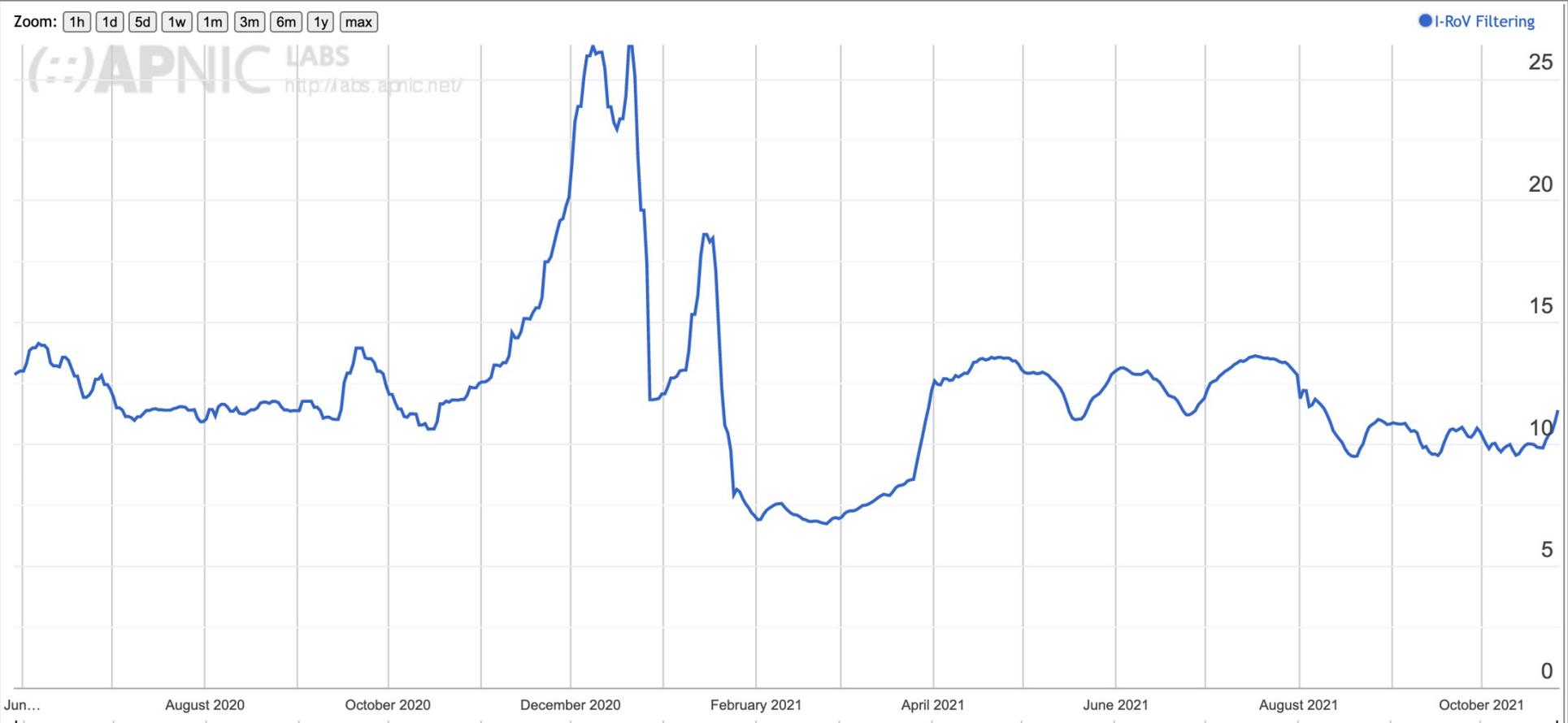


# RPKI ROV Adoption in Europe

Rate of RoV Filtering

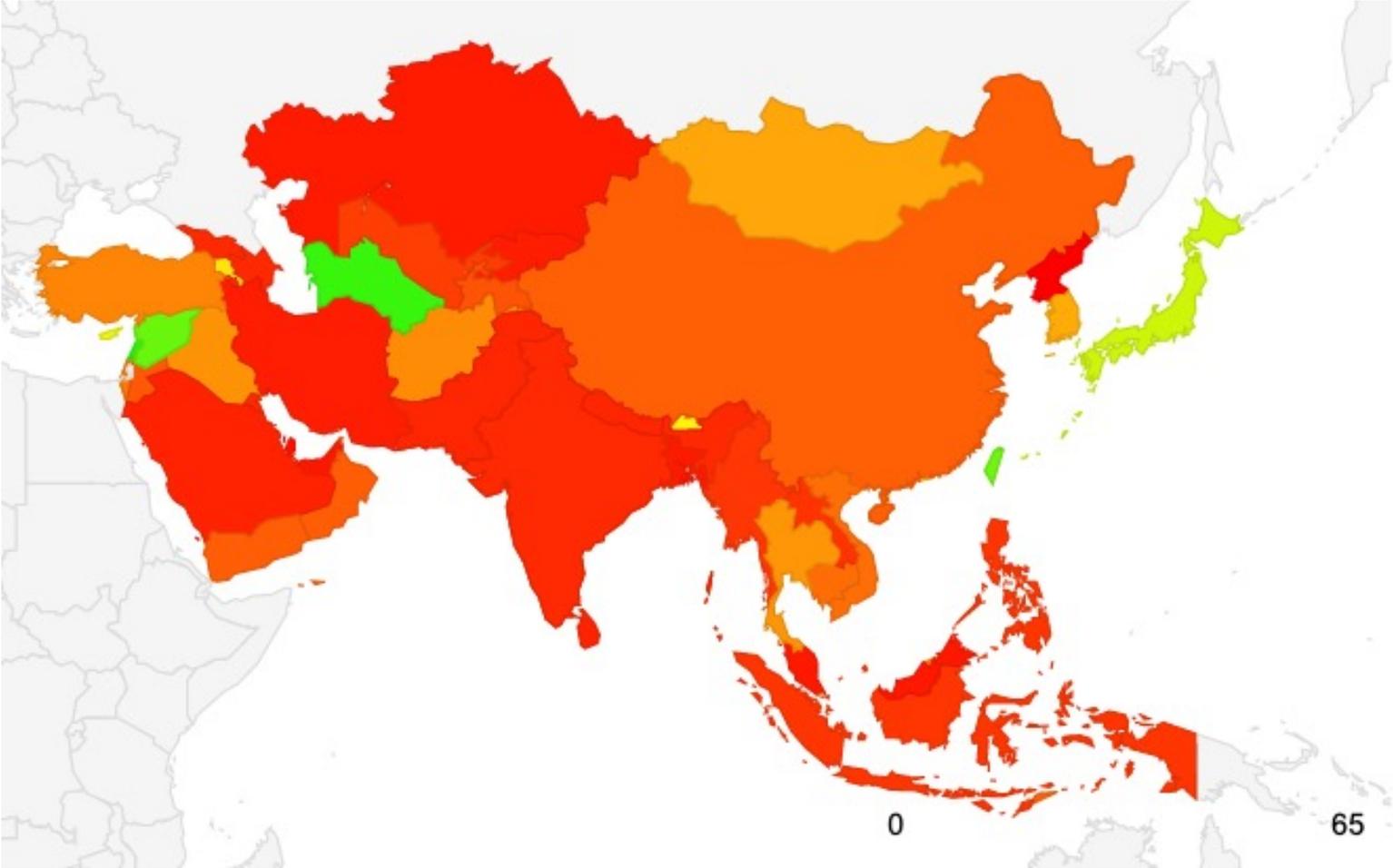


# RPKI ROV - Asia



# RPKI ROV Adoption in Asia

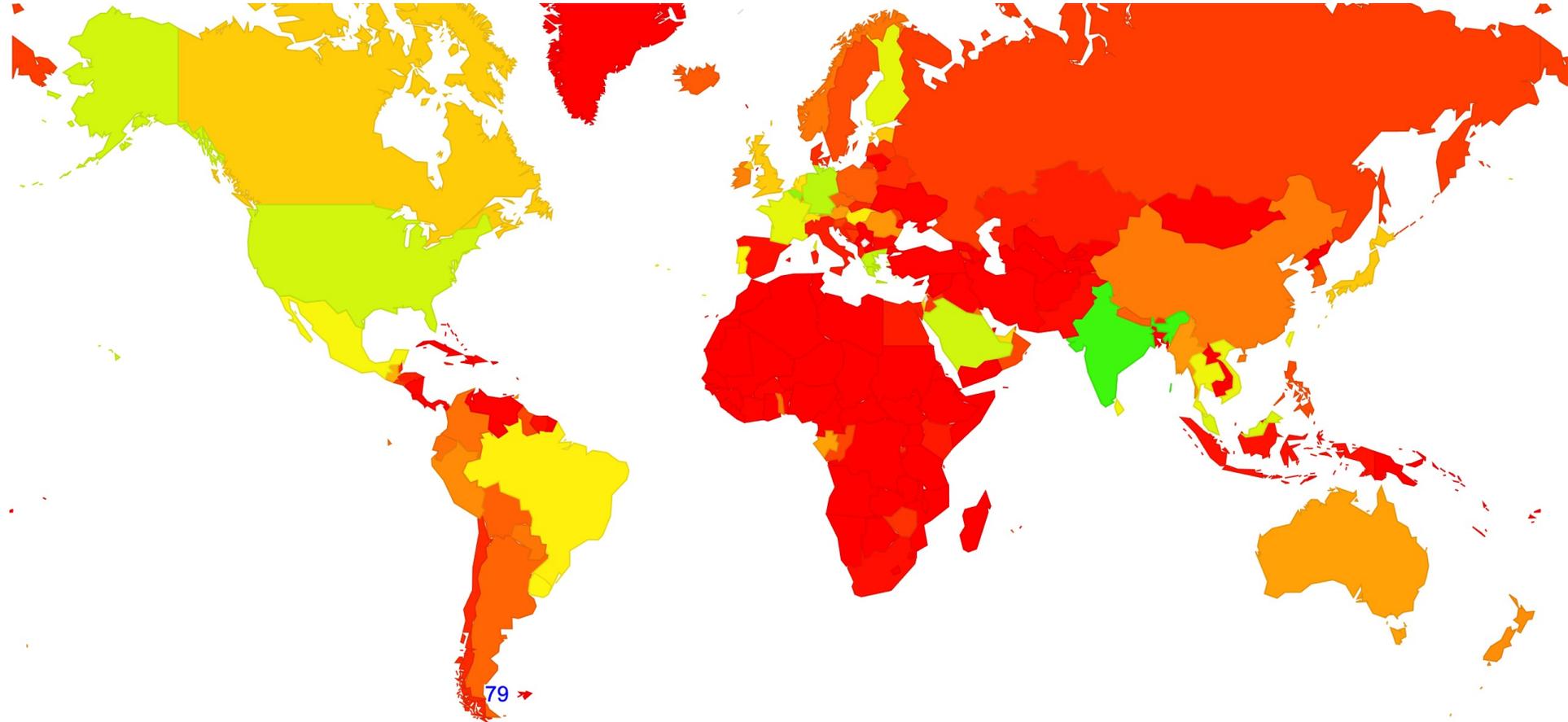
## Rate of RoV Filtering



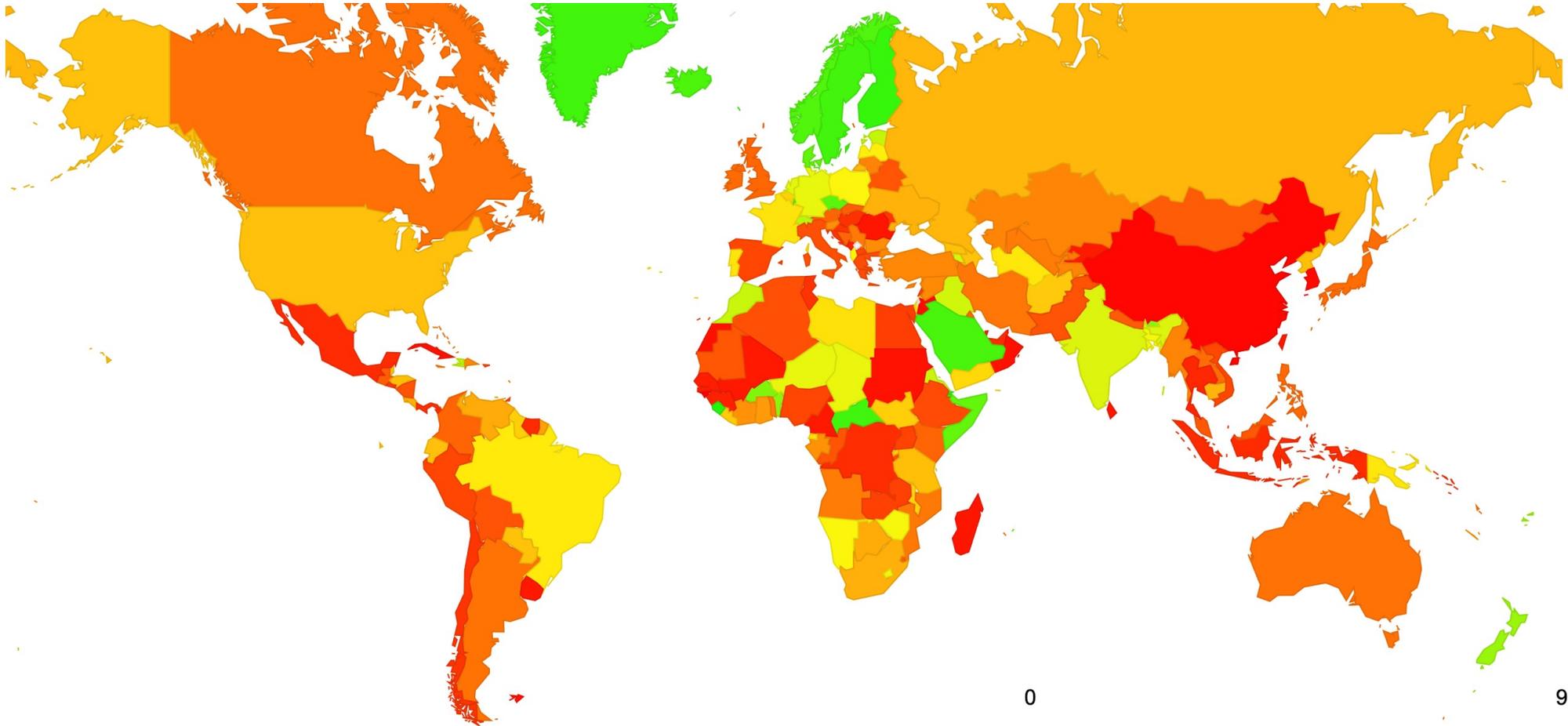
0

65

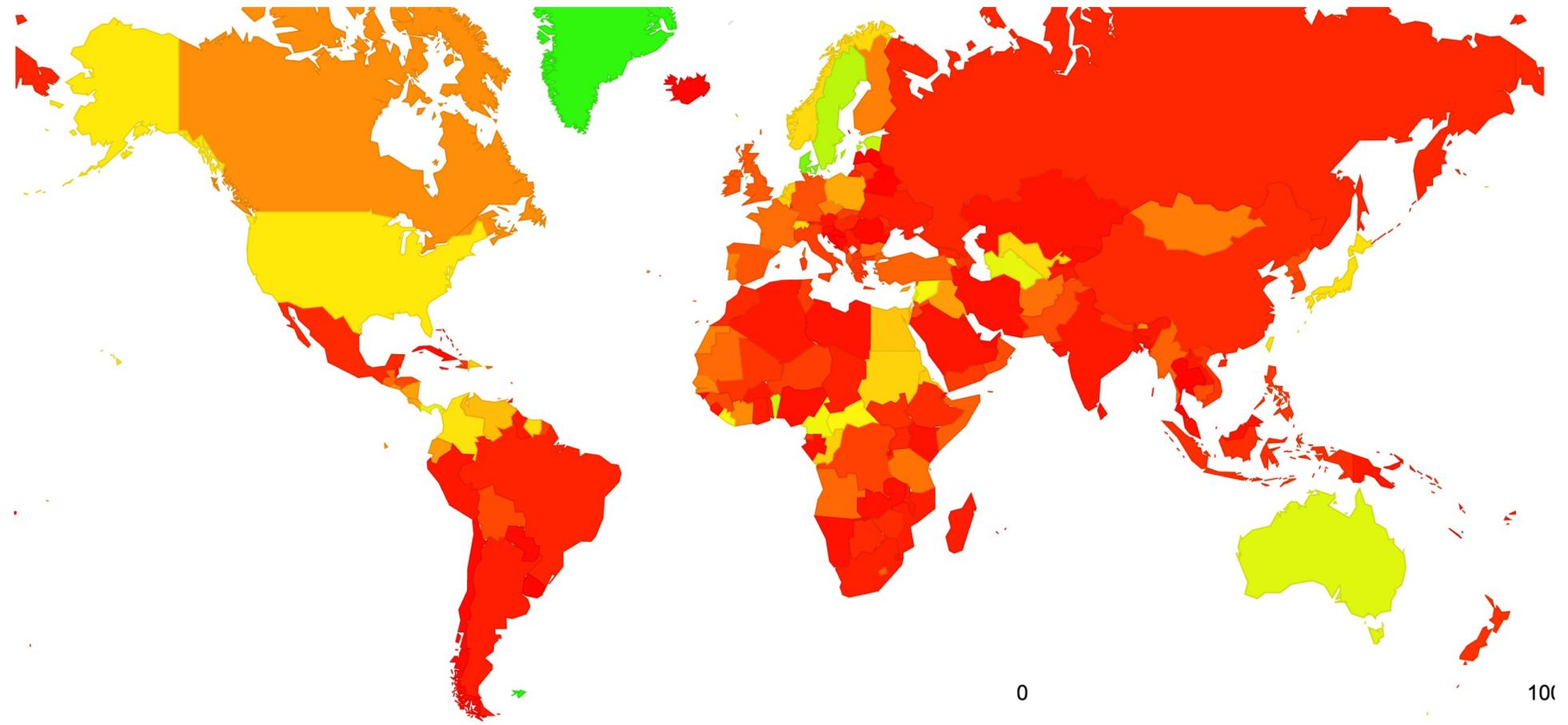
# Global Views - IPv6



# Global Views - DNSSEC



# Global Views - RoV



# Why is there such diversity in deployment?

- IPv6 was promised to offer a simpler, scalable and in theory a more secure Internet
  - IPv6 has been around for 20 years
- DNSSEC was promised to provide a trustable DNS that was impervious to lies and tampering
  - DNSSEC has been around for 10 years
- RoV was meant to protect us from routing mishaps and attacks
  - RoV has been around for 5 years

# Why don't we get it?

- All of these technologies were intended to support a bigger and more secure network environment that was more resistant to various forms of attack
- You would think that users would want this!
  - And they probably would prefer to have this
- You would think that service providers would want this!
  - And I guess that they also would prefer to have this

# Why don't we get it?

- All of these technologies were intended to provide a secure network environment that is resistant to various forms of attack
  - And they were intended to be deployed in a bigger and more secure environment
- You would think that this is the way to have this
  - And they were intended to be deployed in a bigger and more secure environment
- You would think that service providers would want this!
  - And they were intended to be deployed in a bigger and more secure environment

*So why is it so damn hard to deploy it?*

# Maybe its deregulation of this industry

- Noone is telling us what to do
  - Or when to do it
  - It's up to us
- 
- And we all see this differently

# Some providers see advantage in early adoption

- Competitive positioning in a diverse market
- Early adoption of future mainstream technologies (first user advantage)
- Perception of enhanced utility, security and safety in these more recent technologies

# Others see reasons to wait ...

- **IPv6** is a 1990's technology solution to a 1980's networking architectural challenge – CDN feeder networks do not need globally unique address plans across every device all of the time
- **DNSSEC** is only partially-implemented. If we pushed DNSSEC validation to the edges of the network we're scared that the DNS will slow down to unacceptable levels.
- **RPKI Route Origin Validation** makes DNS route hijacking only slightly harder. More moving parts can introduce fragility, and not necessarily enhance operating stability

# Challenges for adoption:

1. This is a deregulated and competitive environment

No one is telling us what to do any more — these are just markets and each provider makes their own choices



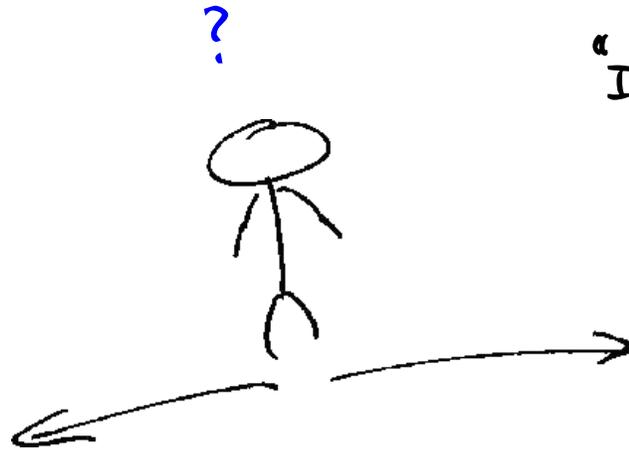
There are many different players  
Each with their own perspective



And all potential approaches will be explored!

# Challenges for adoption:

## 2. The myth of long-term planning



"IPv6 Transition will take many years...

5 years, maybe 10 years, maybe longer"

Are we still firmly committed to the plans we had 5 years ago? How about our 10-year-old plans?

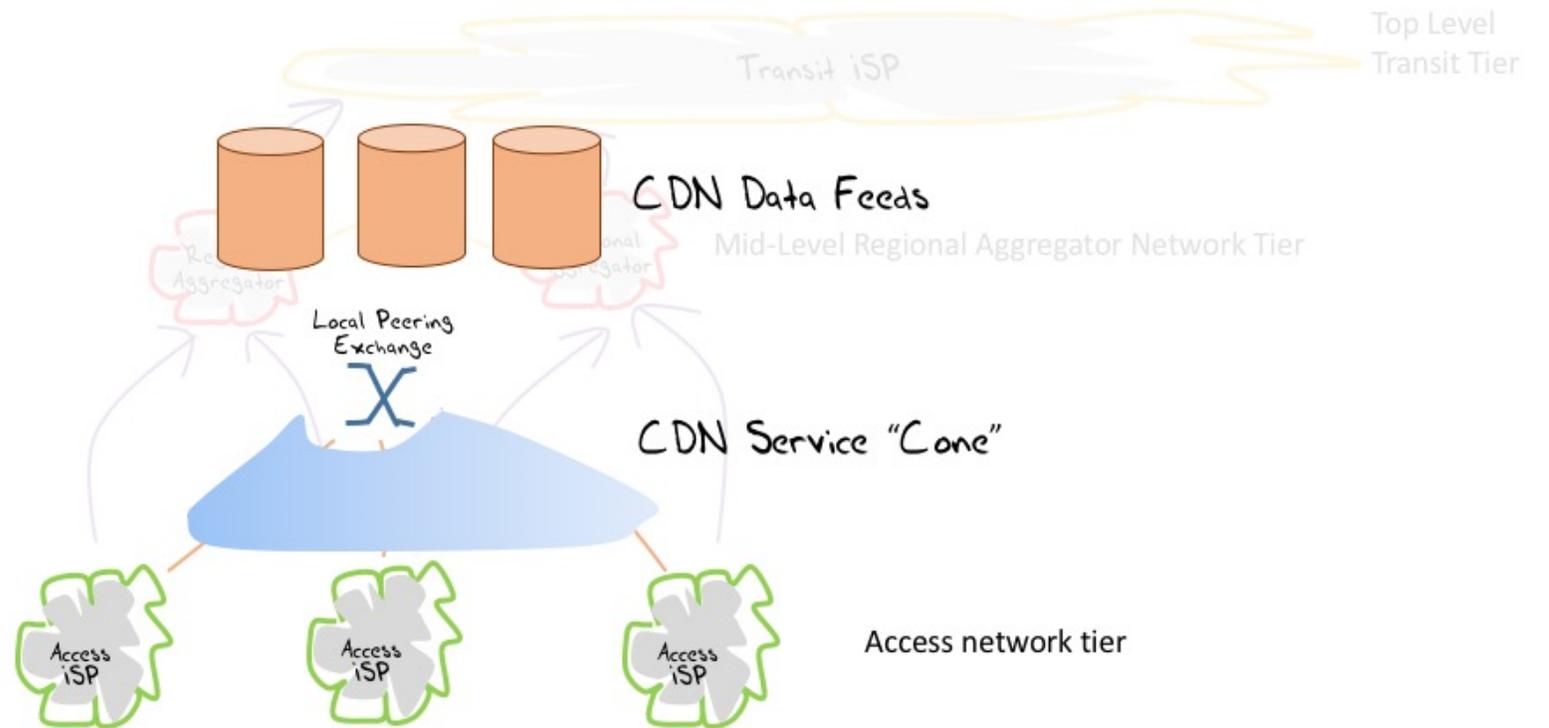
The longer the period of transition, the higher the risk of completely losing the plot and heading into other directions!

# Challenges for adoption:

## 3. The Internet keeps changing

### Today's Internet Architecture

What network model are we building for?  
Will dense deployment of data centres completely replace the need for transit services?+



Let's return to Mongolia



# Let's return to Mongolia

And see which service providers have adopted each of these technologies

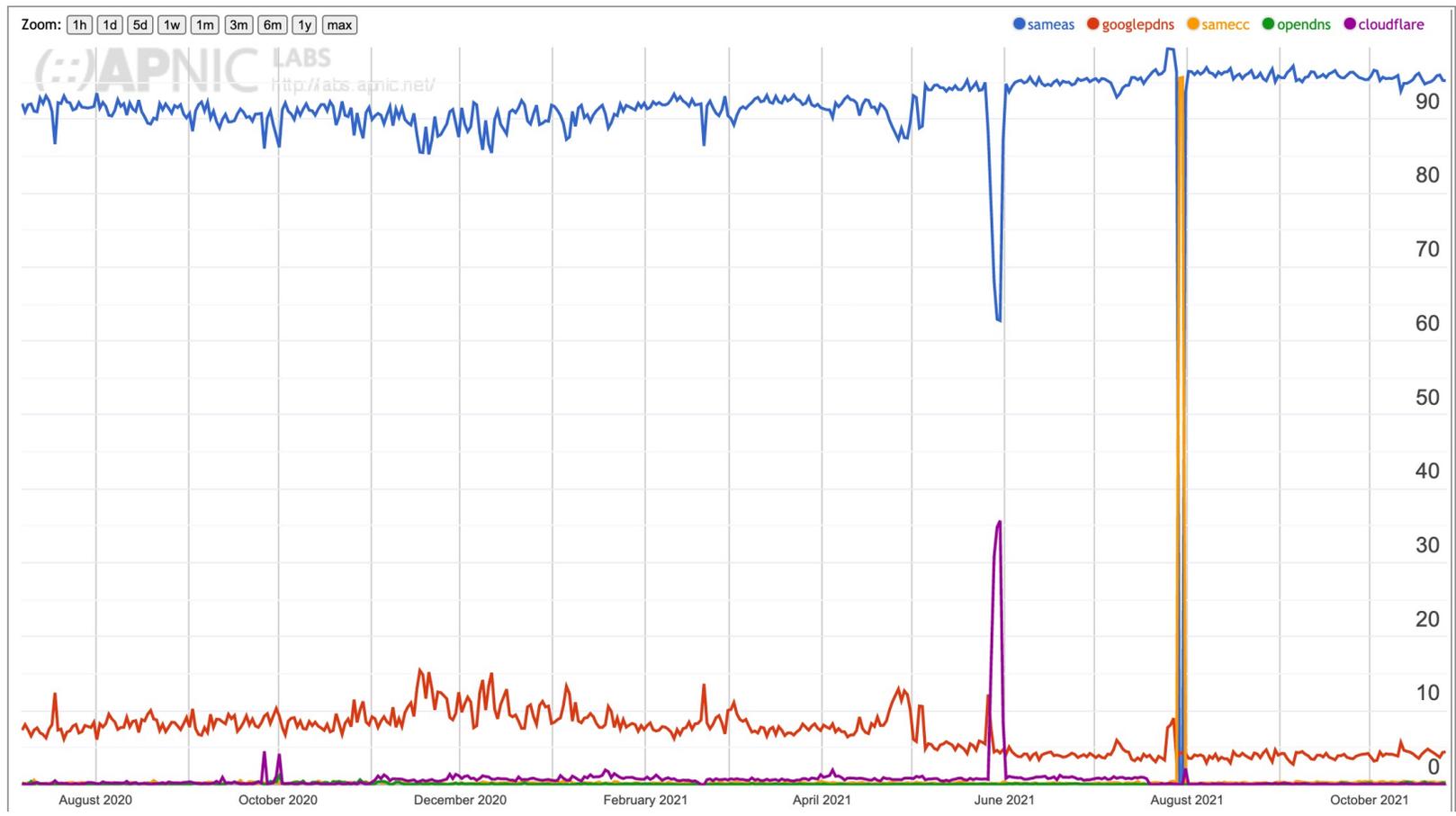
# Mongolian ISPs and DNSSEC

| ASN      | AS Name   | DNSSEC Validates | Partial Validation | Samples |
|----------|---|------------------|--------------------|---------|
| AS55805  | MOBICOM-AS-MN MobiCom Corporation   | 84.99%           | 15.00%             | 68,269  |
| AS134356 | NBCCOLTD-AS-AP NBC Co.,Ltd  | 84.60%           | 15.32%             | 2,533   |
| AS24320  | RAILCOM Railcom - Commercial Center   | 84.58%           | 14.60%             | 493     |
| AS9484   | MOBINET-AS-MN Mobinet LLC. AS Mobinet Internet Service Provider   | 77.85%           | 20.74%             | 7,892   |
| AS58598  | COMTEL-NET-AS Mongolia  | 77.27%           | 22.73%             | 88      |
| AS141681 | IMNL-AS-AP IN Mobile Network LLC  | 76.87%           | 23.13%             | 134     |
| AS58439  | ICNC-AS ICNC LLC  | 76.09%           | 23.91%             | 138     |
| AS45204  | GEMNET-MN GEMNET LLC  | 74.58%           | 21.19%             | 118     |
| AS45237  | GLOBAL-MG-AS-AP Magicnet LLC  | 73.61%           | 23.61%             | 72      |
| AS10076  | ASN-ERDEMNET # AS-ERDEMNET CONVERTED TO ASN-ERDEMNET FOR RPSL COMPLIANCE ERDEMNET Mongolian National Research and Education Network | 68.31%           | 23.94%             | 142     |
| AS63962  | ITTOOLS-AS iTools JSC   | 56.21%           | 32.68%             | 153     |
| AS58625  | GMOBILENET-MN Ulaanbaatar-211213. Chingeltei district   | 41.67%           | 58.33%             | 132     |
| AS139579 | MNL-AS-AP Mongolsat Networks LLC  | 41.07%           | 23.21%             | 56      |
| AS17882  | ASN-MCS-AP # AS-MCS-AP CONVERTED TO ASN-MCS-AP FOR RPSL COMPLIANCE The first E-commerce and TriplePlay Service ISP in Mongolia.     | 33.19%           | 27.87%             | 239,738 |
| AS10109  | TOPNET-AS-MN-AP Topica LLC, Internet Service Provider,Ulaanbaatar, Mongolia   | 25.35%           | 21.13%             | 71      |
| AS4850   | DIGICOM-AS-AP Digicom LLC   | 15.15%           | 19.70%             | 66      |
| AS24559  | GMOBILE-MN G-Mobile Corporation   | 14.19%           | 85.76%             | 8,568   |
| AS38818  | YOKOUNANET-MN-AS-AP YOKOZUNANET LLC   | 13.15%           | 62.53%             | 403     |

Good

not good!

# Mongolia and DNS Resolvers



ISP resolver

Google 8.8.8.8

# Mongolian ISPs and DNS Resolvers

| ASN      | AS Name   | sameas  | googlepdns | samecc  | opendns | diffcc | cloudflare | Samples |
|----------|---|---------|------------|---------|---------|--------|------------|---------|
| AS17882  | ASN-MCS-AP # AS-MCS-AP CONVERTED TO ASN-MCS-AP FOR RPSL COMPLIANCE The first E-commerce and TriplePlay Service ISP in Mongolia.     | 98.590% | 1.452%     | 0.060%  | 0.055%  | 0.031% | 0.031%     | 37,374  |
| AS55805  | MOBICOM-AS-MN MobiCom Corporation   | 99.232% | 0.721%     | 0.113%  | 0.012%  | 0.007% | 0.017%     | 12,289  |
| AS10219  | SKYCC-AS-MAIN SKYMEDIA CORPORATION LLC  | 98.410% | 1.123%     | 0.268%  | 0.011%  | 0.294% | 0.037%     | 7,786   |
| AS9484   | MOBINET-AS-MN Mobinet LLC. AS Mobinet Internet Service Provider   | 87.483% | 10.099%    | 0.544%  | 1.743%  | 1.564% | 0.453%     | 1,527   |
| AS24559  | GMOBILE-MN G-Mobile Corporation   | 0.160%  | 99.864%    | 0.045%  | 0.000%  | 0.030% | 0.093%     | 1,443   |
| AS9934   | MICOM-MN-AS Mongolia Telecom  | 94.774% | 4.230%     | 5.008%  | 0.000%  | 0.052% | 0.012%     | 836     |
| AS56293  | KEWIKONET-AS-AP Kewiko LLC  | 98.648% | 1.377%     | 0.082%  | 0.018%  | 0.015% | 0.075%     | 605     |
| AS134356 | NBCCOLTD-AS-AP NBC Co.,Ltd  | 99.392% | 0.609%     | 0.059%  | 0.000%  | 0.000% | 0.000%     | 404     |
| AS38805  | CITINET-AS-MN-AP STXCitinet, Leading Internet & VOIP Service Provider, Ulaanbaatar, Mongolia  | 91.350% | 8.337%     | 1.271%  | 0.042%  | 0.129% | 0.217%     | 273     |
| AS38818  | YOKOUNANET-MN-AS-AP YOKOZUNANET LLC   | 1.124%  | 9.072%     | 78.402% | 0.140%  | 0.000% | 19.972%    | 74      |
| AS24320  | RAILCOM Railcom - Commercial Center   | 50.023% | 53.286%    | 0.194%  | 0.000%  | 0.334% | 0.000%     | 62      |
| AS10076  | ASN-ERDEMNET # AS-ERDEMNET CONVERTED TO ASN-ERDEMNET FOR RPSL COMPLIANCE ERDEMNET Mongolian National Research and Education Network | 5.627%  | 2.364%     | 0.000%  | 92.567% | 0.261% | 0.000%     | 50      |
| AS58625  | GMOBILENET-MN Ulaanbaatar-211213. Chingeltei district   | 0.255%  | 90.249%    | 7.681%  | 0.000%  | 0.000% | 3.412%     | 46      |

# Mongolian ISPs and ROA Production

| AS       | AS Name   | V4 Valid ▼ | Pc     | V4 Invalid | Pc   | V4 Unknwn | Pc    | V4 Total Routes | V |
|----------|---|------------|--------|------------|------|-----------|-------|-----------------|---|
| AS17882  | ASN-MCS-AP # AS-MCS-AP CONVERTED TO ASN-MCS-AP FOR RPSL COMPLIANCE The first E-commerce and TriplePlay Service ISP in Mongolia.     | 161        | 100.0% | 0          | 0.0% | 0         | 0.0%  | 161             |   |
| AS9484   | MOBINET-AS-MN Mobinet LLC. AS Mobinet Internet Service Provider   | 78         | 100.0% | 0          | 0.0% | 0         | 0.0%  | 78              |   |
| AS10219  | SKYCC-AS-MAIN SKYMEDIA CORPORATION LLC  | 34         | 100.0% | 0          | 0.0% | 0         | 0.0%  | 34              |   |
| AS9934   | MICOM-MN-AS Mongolia Telecom  | 27         | 100.0% | 0          | 0.0% | 0         | 0.0%  | 27              |   |
| AS45237  | GLOBAL-MG-AS-AP Magicnet LLC  | 17         | 100.0% | 0          | 0.0% | 0         | 0.0%  | 17              |   |
| AS55805  | MOBICOM-AS-MN MobiCom Corporation   | 14         | 93.3%  | 1          | 6.7% | 0         | 0.0%  | 15              |   |
| AS138968 | RAINBOWIDC-AS-AP rainbow network limited  | 12         | 100.0% | 0          | 0.0% | 0         | 0.0%  | 12              |   |
| AS24496  | GNET-AS-MN GNET Co.,Ltd Internet Service Provider Mongolia  | 10         | 100.0% | 0          | 0.0% | 0         | 0.0%  | 10              |   |
| AS45204  | GEMNET-MN GEMNET LLC  | 10         | 83.3%  | 0          | 0.0% | 2         | 16.7% | 12              |   |
| AS24320  | RAILCOM Railcom - Commercial Center   | 8          | 100.0% | 0          | 0.0% | 0         | 0.0%  | 8               |   |
| AS46562  | PERFORMIVE  | 8          | 100.0% | 0          | 0.0% | 0         | 0.0%  | 8               |   |
| AS10109  | TOPNET-AS-MN-AP Topica LLC, Internet Service Provider,Ulaanbaatar, Mongolia   | 7          | 100.0% | 0          | 0.0% | 0         | 0.0%  | 7               |   |
| AS56301  | MN-NDC-MN National Data Center building   | 6          | 100.0% | 0          | 0.0% | 0         | 0.0%  | 6               |   |
| AS133453 | MOGULSS-AS-AP Mogul Service and Support LLC   | 5          | 100.0% | 0          | 0.0% | 0         | 0.0%  | 5               |   |
| AS133177 | WICOM-AS-AP Wicom Networks LLC  | 4          | 100.0% | 0          | 0.0% | 0         | 0.0%  | 4               |   |
| AS135033 | BODISYSTEMSLLC-AS-AP BodiSystems Co. Ltd  | 4          | 100.0% | 0          | 0.0% | 0         | 0.0%  | 4               |   |
| AS10076  | ASN-ERDEMNET # AS-ERDEMNET CONVERTED TO ASN-ERDEMNET FOR RPSL COMPLIANCE ERDEMNET Mongolian National Research and Education Network | 3          | 100.0% | 0          | 0.0% | 0         | 0.0%  | 3               |   |
| AS63962  | ITTOOLS-AS iTools JSC   | 3          | 100.0% | 0          | 0.0% | 0         | 0.0%  | 3               |   |



all good

# Mongolian ISPs and ROV Filtering

| ASN      | AS Name   | RPKI Validates | Samples |
|----------|---|----------------|---------|
| AS63962  | ITOOOLS-AS iTools JSC   | 100.00%        | 106     |
| AS55805  | MOBICOM-AS-MN MobiCom Corporation   | 98.43%         | 47,957  |
| AS9484   | MOBINET-AS-MN Mobinet LLC. AS Mobinet Internet Service Provider   | 98.14%         | 5,385   |
| AS134356 | NBCCOLTD-AS-AP NBC Co.,Ltd  | 46.86%         | 1,752   |
| AS9009   | M247  | 27.84%         | 97      |
| AS45204  | GEMNET-MN GEMNET LLC  | 16.05%         | 81      |
| AS58598  | COMTEL-NET-AS Mongolia  | 11.11%         | 54      |
| AS56293  | KEWIKONET-AS-AP Kewiko LLC  | 9.14%          | 3,174   |
| AS10076  | ASN-ERDEMNET # AS-ERDEMNET CONVERTED TO ASN-ERDEMNET FOR RPSL COMPLIANCE ERDEMNET Mongolian National Research and Education Network | 9.00%          | 100     |
| AS141681 | IMNL-AS-AP IN Mobile Network LLC  | 8.82%          | 102     |
| AS58439  | ICNC-AS ICNC LLC  | 8.08%          | 99      |
| AS38818  | YOKOUNANET-MN-AS-AP YOKOZUNANET LLC   | 7.31%          | 301     |
| AS24320  | RAILCOM Railcom - Commercial Center   | 7.01%          | 371     |
| AS24559  | GMOBILE-MN G-Mobile Corporation   | 6.56%          | 6,403   |
| AS58625  | GMOBILENET-MN Ulaanbaatar-211213. Chingeltei district   | 6.41%          | 78      |
| AS9934   | MICOM-MN-AS Mongolia Telecom  | 5.44%          | 3,696   |
| AS17882  | ASN-MCS-AP # AS-MCS-AP CONVERTED TO ASN-MCS-AP FOR RPSL COMPLIANCE The first E-commerce and TriplePlay Service ISP in Mongolia.     | 5.35%          | 182,729 |
| AS38805  | CITINET-AS-MN-AP STXCitinet, Leading Internet & VOIP Service Provider, Ulaanbaatar, Mongolia  | 4.66%          | 1,244   |
| AS10219  | SKYCC-AS-MAIN SKYMEDIA CORPORATION LLC  | 4.42%          | 36,311  |

↑ good

↓ not good!

# And Mongolian ISPs and IPv6!

| ASN      | AS Name   | IPv6 Capable | IPv6 Preferred | Samples |
|----------|---|--------------|----------------|---------|
| AS17882  | ASN-MCS-AP # AS-MCS-AP CONVERTED TO ASN-MCS-AP FOR RPSL COMPLIANCE The first E-commerce and TriplePlay Service ISP in Mongolia.     | 0.02%        | 0.02%          | 251,030 |
| AS55805  | MOBICOM-AS-MN MobiCom Corporation   | 0.02%        | 0.02%          | 72,403  |
| AS10219  | SKYCC-AS-MAIN SKYMEDIA CORPORATION LLC  | 0.01%        | 0.01%          | 49,374  |
| AS24559  | GMOBILE-MN G-Mobile Corporation   | 0.01%        | 0.01%          | 8,946   |
| AS9484   | MOBINET-AS-MN Mobinet LLC. AS Mobinet Internet Service Provider   | 0.01%        | 0.01%          | 8,283   |
| AS9934   | MICOM-MN-AS Mongolia Telecom  | 0.00%        | 0.00%          | 5,082   |
| AS56293  | KEWIKONET-AS-AP Kewiko LLC  | 0.04%        | 0.04%          | 4,502   |
| AS134356 | NBCCOLTD-AS-AP NBC Co.,Ltd  | 0.00%        | 0.00%          | 2,619   |
| AS38805  | CITINET-AS-MN-AP STXCitinet, Leading Internet & VOIP Service Provider, Ulaanbaatar, Mongolia  | 0.17%        | 0.17%          | 1,776   |
| AS24320  | RAILCOM Railcom - Commercial Center   | 0.00%        | 0.00%          | 500     |
| AS38818  | YOKOUNANET-MN-AS-AP YOKOZUNANET LLC   | 0.00%        | 0.00%          | 416     |
| AS63962  | ITTOOLS-AS iTools JSC   | 0.00%        | 0.00%          | 162     |
| AS10076  | ASN-ERDEMNET # AS-ERDEMNET CONVERTED TO ASN-ERDEMNET FOR RPSL COMPLIANCE ERDEMNET Mongolian National Research and Education Network | 0.00%        | 0.00%          | 150     |
| AS141681 | IMNL-AS-AP IN Mobile Network LLC  | 0.00%        | 0.00%          | 144     |
| AS55408  | MCS-AS-AP Univision LLC   | 0.00%        | 0.00%          | 141     |
| AS58439  | ICNC-AS ICNC LLC  | 0.00%        | 0.00%          | 139     |
| AS58625  | GMOBILENET-MN Ulaanbaatar-211213. Chingeltei district   | 0.78%        | 0.78%          | 128     |
| AS45204  | GEMNET-MN GEMNET LLC  | 0.00%        | 0.00%          | 121     |
| AS131240 | ULTRANETLLC-AS-AP Ultranet Zone LLC   | 0.00%        | 0.00%          | 97      |

all not good!

# And Mongolian ISPs and IPv6!

| ASN      | AS Name   | IPv6 Capable | IPv6 Preferred | Samples |
|----------|---|--------------|----------------|---------|
| AS17882  | ASN-MCS-AP # AS-MCS-AP CONVERTED TO ASN-MCS-AP FOR RPSL COMPLIANCE The first E-commerce and TriplePlay Service ISP in Mongolia.     | 0.02%        | 0.02%          | 251,030 |
| AS55805  | MOBICOM-AS-MN MobiCom Corporation   | 0.02%        | 0.02%          | 72,403  |
| AS10219  | SKYCC-AS-MAIN SKYMEDIA CORPORATION LLC  | 0.01%        | 0.01%          | 49,374  |
| AS24559  | GMOBILE-MN G-Mobile Corporation   | 0.01%        | 0.01%          | 8,946   |
| AS9484   | MOBINET-AS-MN Mobinet LLC. AS Mobinet Internet Service Provider   | 0.01%        | 0.01%          | 8,283   |
| AS9934   | MICOM-MN-AS Mongolia Telecom  | 0.00%        | 0.00%          | 5,082   |
| AS56293  | KEWIKONET-AS-AP Kewiko LLC  | 0.04%        | 0.04%          | 4,502   |
| AS1743   | BC-OLTA-AS-AP BC Co.,Ltd  | 0.00%        | 0.00%          | 2,619   |
| AS3810   | BITIN-AS-MN-AP STXCitinet, Leading Internet & VoIP Service Provider, Ulaanbaatar, Mongolia  | 0.17%        | 0.17%          | 1,776   |
| AS24558  | MAILCOM-AS-AP Mailcom - Commercial Center   | 0.00%        | 0.00%          | 500     |
| AS38813  | YOKOZUNANET-MN-AS-AP YOKOZUNANET LLC  | 0.00%        | 0.00%          | 416     |
| AS63962  | ITTOOLS-AS iTools JSC   | 0.00%        | 0.00%          | 162     |
| AS10076  | ASN-ERDEMNET # AS-ERDEMNET CONVERTED TO ASN-ERDEMNET FOR RPSL COMPLIANCE ERDEMNET Mongolian National Research and Education Network | 0.00%        | 0.00%          | 150     |
| AS141681 | IMNL-AS-AP IN Mobile Network LLC  | 0.00%        | 0.00%          | 144     |
| AS55408  | MCS-AS-AP Univision LLC   | 0.00%        | 0.00%          | 141     |
| AS58439  | ICNC-AS ICNC LLC  | 0.00%        | 0.00%          | 139     |
| AS58625  | GMOBILENET-MN Ulaanbaatar-211213. Chingeltei district   | 0.78%        | 0.78%          | 128     |
| AS45204  | GEMNET-MN GEMNET LLC  | 0.00%        | 0.00%          | 121     |
| AS131240 | ULTRANETLLC-AS-AP Ultranet Zone LLC   | 0.00%        | 0.00%          | 97      |

WHY SO LOW?

all not good!

Thanks!