The Internet Routing Table using RouteViews

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btNOG11, Thimphu

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RouteViews Background

- A growing network of 40+ collectors positioned strategically at Internet Exchange Points around the world
- RouteViews collaborates with the Center for Applied Internet Data Analysis (CAIDA) working with NSF grants that support Designing a Global Measurement Infrastructure to Improve Internet Security, GMI3S (OAC-2131987), and an Integrated Library for Advancing Network Data Science, ILANDS (CNS-2120399).
- RouteViews is supported with financial and in-kind donations by multiple organizations

- **RouteViews is based at the University of Oregon and operated by NSRC**
- NSRC supports the growth of global Internet infrastructure by providing engineering assistance, collaborative technical workshops, training, and other resources to university, research & education networks worldwide.
- NSRC is partially funded by the IRNC program of the NSF (OAC-2029309) and Google with other contributions from public and private organizations.
- The University of Oregon is a public research institution in Eugene, Oregon, USA founded in 1876.

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What is RouteViews

- A tool that allows Internet network operators to look at the BGP table from different backbones and locations around the world to troubleshoot and to assess:
  - Reachability, hijacks, bugs, peer visibility, mass withdrawals, RPKI status,…
- Operators who find it a valuable tool also peer to contribute to the value
- RouteViews operates collectors strategically positioned at IXPs around the world.
  - It also hosts a few multi-hop collectors at UO for those operators who are not present at IXPs.

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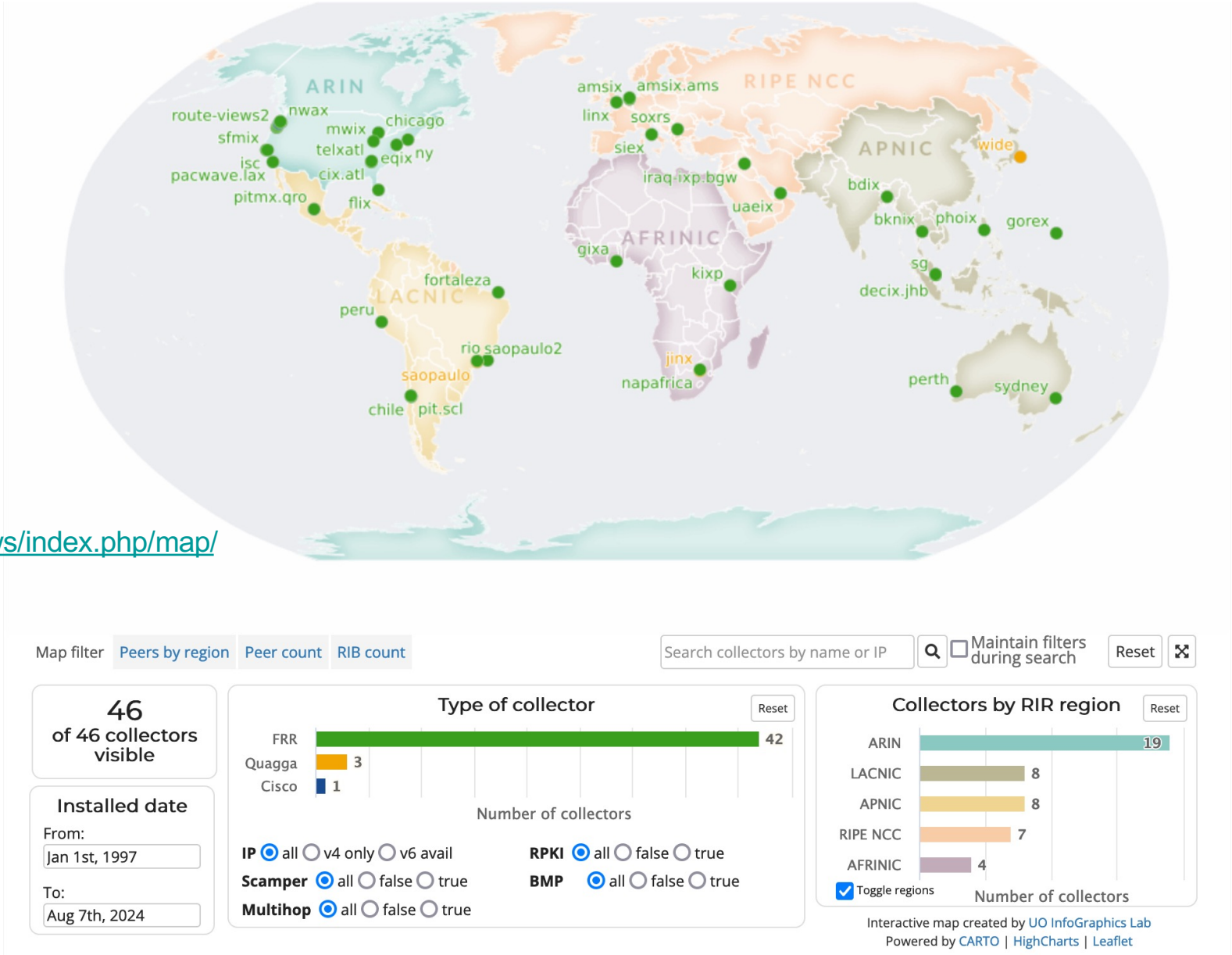
RouteViews Collector Map



http://www.routeviews.org/routeviews/index.php/map/

RouteViews News

- Collectors:
  - The majority use FRR[1] (either version 9.1.1 or 10.0.1)
  - One Cisco ASR1004 and one (still) using Quagga
  - Moving collectors from metal to VMs (easier deployment & management)
- Location update:
  - Recent additions include CIX-ATL, PacWave LAX, PIT Mexico & Santiago, DE-CIX Johor Bahru, Iraq IX
  - Several new locations offered; resources required to fulfil those offers

[1]FRRouting Project: https://frrouting.org/

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RouteViews Development Projects

- API
  - Allow programmatic access to live RouteViews data
  - (our collectors currently allow telnet access, which 1000s of automated scripts hammer on a daily basis)
- LookingGlass
  - telnet access is unsustainable
  - Aim to making LookingGlass default access for each collector
    - telnet available on one collector for legacy
- BMP
  - Live feed from collectors for BGP data consumers

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RouteViews Behind the Scenes Projects

- Months of ongoing effort:
  - Upgrading archive infrastructure and storage
    - RouteViews stores BGP data from 1997 – around 50 Tbytes (compressed)
  - Tooling
    - Automation tools for managing the whole infrastructure and deploying new peers
  - Collector OS (from CentOS to Ubuntu)
    - CentOS end-of-life – half the collectors still running CentOS
  - FRR performance
    - Standardising on two latest releases, upgrading from old releases
    - “Badly behaving peers” (aka slow peers)

RouteViews Future Planning

- Collectors & hosts in new locations outside North America
  - Large IXPs with dense interconnection
  - Unique or specialist environments (eg R&E exchanges)
- Scalable and diverse archiving
- Improved community support
  - Running this infrastructure costs money!
  - We hugely appreciate our generous supporters
    - https://www.routeviews.org/routeviews/index.php/supporters/
- Your suggestions are very welcome! 🙏

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Using RouteViews

- Network Operators use the live data to analyse how their routes appear on the Global Routing System
- Researchers use the 27-year-old data archive to study trends, route hijacks, and changes such as:
  - Origin change
  - Next-hop change
  - New prefix / more specifics
  - New neighbours
  - Operator ASN appearing in a new transit path
  - Bogons

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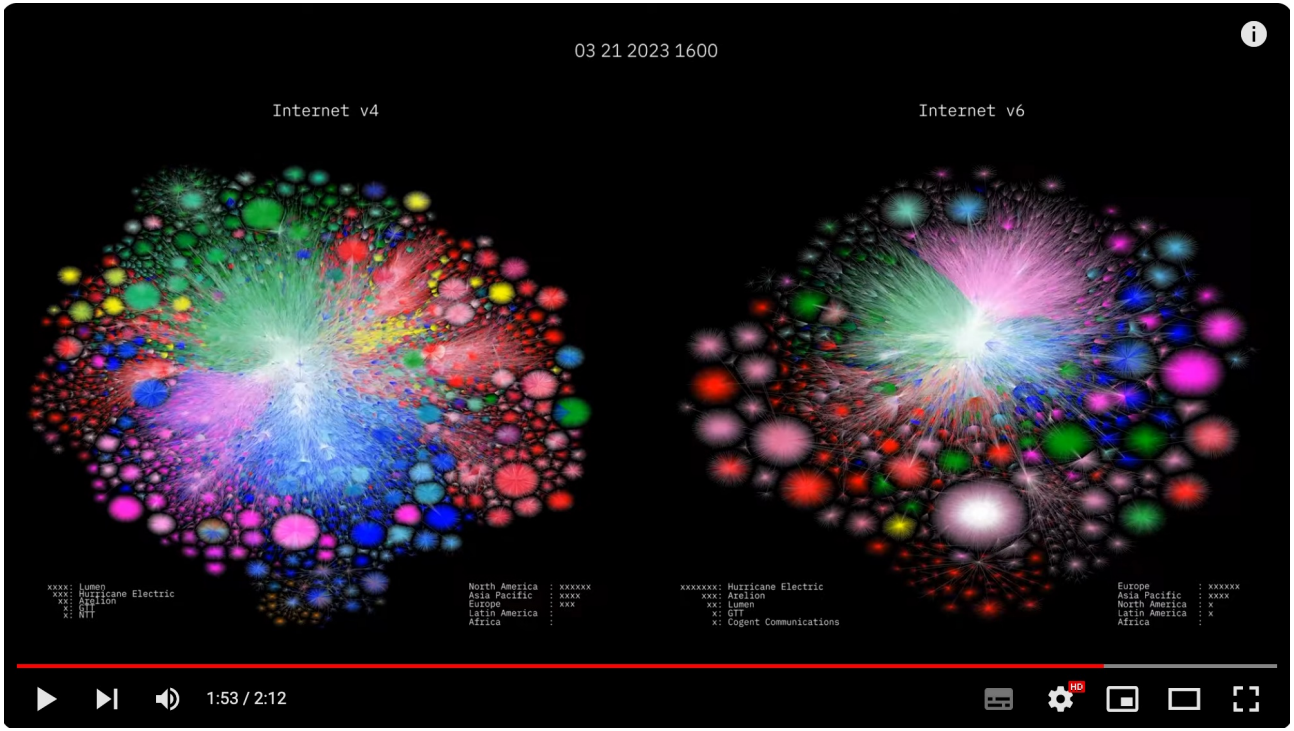
RouteViews Impact



Barrett Lyon: https://www.youtube.com/watch?v=vo5glK9czIE

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Use Cases – Multihop Collector

```
route-views2.routeviews.org> sh bgp sum

IPv4 Unicast Summary (VRF default):
BGP router identifier 128.223.51.102, local AS number 6447 vrf-id 0
BGP table version 2376140
RIB entries 1842070, using 169 MiB of memory
Peers 32, using 644 KiB of memory

Neighbor        V         AS   MsgRcvd   MsgSent   TblVer  InQ OutQ  Up/Down State/PfxRcd   PfxSnt Desc
12.0.1.63       4       7018    278377       377  2376140    0    0 06:14:18        938553        0 ATT
37.139.139.17   4      57866    281167       751  2376140    0    0 06:14:18        941733        0 Fusix
45.61.0.85      4      22652    430462       754  2376140    0    0 05:30:45        943602        0 FIBRENOIRE
62.115.128.137  4       1299   1145666       377  2376140    0    0 06:14:18        919817        0 Telia
64.71.137.241   4       6939    222621       376  2376140    0    0 06:14:18        961672        0 Hurricane Electric
77.39.192.30    4      20912    199676      2247  2376140    0    0 06:14:18        942334        0 PANSERVICE
87.121.64.4     4      57463    124693       375  2376140    0    0 06:13:35        483102        0 NETIXLTD
89.149.178.10   4       3257    301777       377  2376140    0    0 06:14:18        939075        0 Tiscali
91.218.184.60   4      49788    280255       376  2376140    0    0 06:14:18        943183        0 NEXTHOPNO
94.156.252.18   4      34224    365615       376  2376140    0    0 06:14:17        965856        0 NETERRA
105.16.0.247    4      37100    304500       746  2376140    0    0 06:11:16        942394        0 SEACOM
129.250.1.71    4       2914    267752       751  2376140    0    0 06:14:18        939523        0 NTT-A
137.164.16.84   4       2152    219827       376  2376140    0    0 06:14:18        941035        0 CENIC
140.192.8.16    4      20130    247609       751  2376140    0    0 06:14:18        964417        0 DEPAULEDU
144.228.241.130 4       1239      4442       377  2376140    0    0 06:14:17         45863        0 Sprint
147.28.7.1      4       3130       421       376  2376140    0    0 06:14:18            14        0 RGnet, LLC
```

32 peers, multi-hop

Lots of full tables

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Use Cases – Weird Announcements

```
route-views7.routeviews.org> sh ip bgp 45.181.4.0/24
BGP routing table entry for 45.181.4.0/24, version 54948963
Paths: (8 available, best #2, table default)
  Not advertised to any peer
...
924 835 16735 53062 262698 269289
    185.121.168.42 from 185.121.168.42 (10.20.30.40)
      Origin IGP, valid, external, best (Older Path), rpki validation-state: not found
      Community: 835:11103 924:90 924:601 924:690 16735:111 16735:7000 16735:7203 16735:53062 24115:16735 24115:24115 24115:65023
      53062:10020 53062:10021 53062:30004 53062:30007 53062:30009 53062:30011 53062:30013 53062:30045 53062:30049 53062:30058
      53062:30091 53062:30092 53062:30105 53062:30114 53062:30115 53062:30117 53062:30122 53062:30130 53062:30136 53062:30152
      53062:30156 53062:30161 53062:30168 53062:30182 53062:30183 53062:30184 53062:30185 53062:30186 53062:30187 53062:30188
      53062:30191 53062:30198 53062:30200 53062:30203 53062:30208 53062:30217 53062:30222 53062:30228 53062:30232 53062:30235
      53062:30239 53062:30244 53062:30250 53062:30255 53062:30263 53062:30274 53062:30278 53062:30287 53062:30291 53062:30296
      53062:30301 53062:30305 53062:30317 53062:30328 53062:30344 53062:30355 53062:30357 53062:30369
      Large Community: 924:1:90 924:600:90 924:601:101 24115:1000:2 24115:1001:1 24115:1002:1 24115:1003:26 24115:1004:16735
      53062:11:3692 53062:12:81 53062:13:48
      Last update: Thu Jun 20 04:03:53 2024
 37989 18106 263444 262316 269289 269289 269289 269289 269289 269289 269289 269289 269289 269289 269289 269289 269289 269289
      269289 269289 269289 269289 269289 269289 269289 269289 269289 269289 269289 269289 269289 269289 269289 269289 269289
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      269289 269289 269289 269289 269289 269289 269289 269289 269289 269289 269289 269289 269289 269289
    203.123.48.6 from 203.123.48.6 (203.123.48.6)
      Origin IGP, valid, external, rpki validation-state: not found
      Community: 13538:2000
      Last update: Sun Jun 16 10:17:30 2024
```

What is AS53062 trying to achieve with all these communities??

What is AS269289 trying to achieve by prepending 101 times??

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Use Cases – Invalid ROAs

```
route-views.phoix.routeviews.org> sh ip bgp rpki invalid
BGP table version is 14686437, local router ID is 198.32.172.137, vrf id 0
Default local pref 100, local AS 6447
Status codes:  s suppressed, d damped, h history, * valid, > best, = multipath,
               i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes:  i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

    Network          Next Hop            Metric LocPrf Weight Path
I*> 1.6.168.0/24     198.32.172.156           0             0 142271 9304 6453 4755 9583 ?
I*> 1.6.169.0/24     198.32.172.156           0             0 142271 9304 6453 4755 9583 i
I*> 1.6.183.0/24     198.32.172.156           0             0 142271 9304 6453 4755 9583 i
I*> 1.6.219.0/24     198.32.172.156           0             0 142271 9304 6453 4755 9583 137130 i
I*> 1.6.247.0/24     198.32.172.156           0             0 142271 9304 6453 4755 9583 i
I*> 1.7.178.0/24     198.32.172.156           0             0 142271 9304 6453 4755 9583 137130 i
I*> 1.7.191.0/24     198.32.172.156           0             0 142271 9304 6453 4755 9583 137130 i
I*> 1.7.205.0/24     198.32.172.156           0             0 142271 9304 6453 4755 9583 140202 i
I*> 1.7.228.0/24     198.32.172.156           0             0 142271 9304 6453 4755 9583 137130 i
I*> 1.44.160.0/23    198.32.172.156           0             0 142271 9304 7473 7474 ?
...
```

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Use Cases – Valid ROAs

```
route-views.phoix.routeviews.org> sh ip bgp rpki valid
BGP table version is 14686899, local router ID is 198.32.172.137, vrf id 0
Default local pref 100, local AS 6447
Status codes:  s suppressed, d damped, h history, * valid, > best, = multipath,
               i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes:  i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

    Network          Next Hop            Metric LocPrf Weight Path
V*> 1.0.0.0/24       198.32.172.170                         0 150000 150000 150000 150000 150000 18233 135607 13335 i
V*  1.0.4.0/22       198.32.172.170                         0 150000 150000 150000 150000 150000 18233 135607 7545 2764 38803 i
V*>                  198.32.172.156           0             0 142271 135607 7545 2764 38803 i
V*  1.0.5.0/24       198.32.172.170                         0 150000 150000 150000 150000 150000 18233 135607 7545 2764 38803 i
V*>                  198.32.172.156           0             0 142271 135607 7545 2764 38803 i
V*  1.0.64.0/18      198.32.172.170                         0 150000 150000 150000 150000 150000 18233 135607 174 2497 7670 18144 i
V*>                  198.32.172.156           0             0 142271 174 2519 7670 18144 i
V*> 1.1.1.0/24       198.32.172.170                         0 150000 150000 150000 150000 150000 18233 135607 13335 i
V*  1.6.0.0/22       198.32.172.170                         0 150000 150000 150000 150000 150000 18233 135607 9583 i
V*>                  198.32.172.156           0             0 142271 135607 9583 i
V*  1.6.1.0/24       198.32.172.170                         0 150000 150000 150000 150000 150000 18233 135607 9583 i
V*>                  198.32.172.156           0             0 142271 135607 9583 i
V*  1.6.2.0/24       198.32.172.170                         0 150000 150000 150000 150000 150000 18233 135607 9583 i
V*>                  198.32.172.156           0             0 142271 135607 9583 i
...
```

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Routing Table Analysis – Motivation

- 1998: No one was publishing any Internet routing table analysis
  - Only CIDR-Report reporting on top 20 contributors to routing table, and top 20 bad aggregators
- With support of APNIC, my weekly report started in February 1999
  - https://thyme.apnic.net
  - Started recording global IPv6 table in September 2010
- With NSRC support, started recording the global R&E table in May 2021
  - https://bgp.nsrc.org/REN
- Weekly reports from these record:
  - Routing table size
  - CIDR-Report style reporting on a per-RIR basis
  - …and many other interesting features

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IPv4 Routing Report 4th August 2024

BGP routing table entries examined:	954998
Prefixes after maximum aggregation (per Origin AS):	364071
Deaggregation factor:	2.62
Unique aggregates announced (without unneeded subnets):	464729
Total ASes present in the Internet Routing Table:	75980
Prefixes per ASN:	12.57
Origin-only ASes present in the Internet Routing Table:	65088
Origin ASes announcing only one prefix:	26724
Transit ASes present in the Internet Routing Table:	10892
Transit-only ASes present in the Internet Routing Table:	523
Average AS path length visible in the Internet Routing Table:	4.4
Max AS path length visible:	84
Max AS path prepend of ASN (152107)	80
Prefixes from unregistered ASNs in the Routing Table:	964
Number of instances of unregistered ASNs:	975
Special use prefixes present in the Routing Table:	1
Prefixes being announced from unallocated address space:	520
Number of addresses announced to Internet:	3026844288
Equivalent to 180 /8s, 105 /16s and 250 /24s	
Total number of prefixes smaller than registry allocations:	312091

Global per AS IPv4 prefix count summary

ASN	No of nets	/20 equiv	Max Agg	Description
8151	11831	3290	513	UNINET, MX
16509	10380	11575	3709	AMAZON-02, US
9808	9869	8747	79	CHINAMOBILE-CN China Mobile Communications Group
12479	7711	1708	145	UNI2-AS, ES
7545	5662	840	662	TPG-INTERNET-AP TPG Telecom Limited, AU
4538	4934	4192	74	ERX-CERNET-BKB China Education and Research Netwo
11492	4624	307	545	CABLEONE, US
39891	4521	271	59	ALJAWWALSTC-AS, SA
18403	4229	347	23	FPT-AS-AP FPT Telecom Company, VN
7155	4166	287	88	VIASAT-SP-BACKBONE, US
7552	3965	1331	21	VIETEL-AS-AP Viettel Group, VN
20940	3836	3396	133	AKAMAI-ASN1, NL
9498	3793	511	263	BBIL-AP BHARTI Airtel Ltd., IN
174	3781	8787	882	COGENT-174, US
7713	3638	1044	66	TELKOMNET-AS-AP PT Telekomunikasi Indonesia, ID
6327	3595	1320	79	SHAW, CA
9009	3569	305	1842	M247, RO
10620	3531	493	934	Telmex Colombia S.A., CO
22773	3422	3035	188	ASN-CXA-ALL-CCI-22773-RDC, US
749	3258	54898	2510	DNIC-AS-00749, US

AfriNIC APNIC ARIN LACNIC RIPE NCC

What about IPv6 ?

IPv6 Routing Report 4th August 2024 (Singapore)

BGP routing table entries examined:	200687
Number of IPv6 prefixes with a valid ROA:	121228
Number of IPv6 prefixes with an invalid ROA:	607
Number of IPv6 prefixes with no ROA:	78852
Total ASNs present in the IPv6 Routing Table:	33030
Average AS path length:	4.8
Longest AS path:	27
Total Origin ASNs present in the IPv6 Routing Table:	32728
Paths with bogon ASNs present in the IPv6 Routing Table:	2

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Global IPv6 per AS prefix count summary (Singapore)

ASN	No of Nets	Description
11172	7098	Alestra, S. de R.L. de C.V., MX
9808	5030	CHINAMOBILE-CN China Mobile Communications Group Co., Ltd., CN
16509	5015	AMAZON-02, US
18403	3912	FPT-AS-AP FPT Telecom Company, VN
7552	3045	VIETEL-AS-AP Viettel Group, VN
45609	2844	BHARTI-MOBILITY-AS-AP Bharti Airtel Ltd. AS for GPRS Service, IN
24547	2039	CMNET-V4HEBEI-AS-AP Hebei Mobile Communication Company Limited,
45271	1831	ICLNET-AS-AP Idea Cellular Limited, IN
13335	1582	CLOUDFLARENET, US
17622	1526	CNCGROUP-GZ China Unicom Guangzhou network, CN
28573	1483	Claro NXT Telecomunicacoes Ltda, BR
38266	1413	VIL-AS-AP Vodafone Idea Ltd, IN
12479	1372	UNI2-AS, ES
39891	1363	ALJAWWALSTC-AS, SA
36183	1316	AKAMAI-AS, US
17072	1290	TOTAL PLAY TELECOMUNICACIONES SA DE CV, MX
6167	1220	CELLCO-PART, US
22773	1216	ASN-CXA-ALL-CCI-22773-RDC, US
32098	1202	TRANSTELCO-INC, US
56046	1174	CMNET-JIANGSU-AP China Mobile communications corporation, CN

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Number of IPv4 prefixes announced by prefix length

/1:0	/2:0	/3:0	/4:0	/5:0	/6:0	/7:0	/8:16
/9:16	/10:37	/11:92	/12:294	/13:575	/14:1163	/15:2058	/16:13186
/17:8273	/18:13724	/19:24684	/20:44342	/21:51891	/22:111633	/23:100077	/24:582214
/25:723	/26:0	/27:0	/28:0	/29:0	/30:0	/31:0	/32:0

4th August 2024 ↑

4th August 2023 ↓

/1:0	/2:0	/3:0	/4:0	/5:0	/6:0	/7:0	/8:16
/9:14	/10:39	/11:102	/12:296	/13:575	/14:1197	/15:2072	/16:13489
/17:8275	/18:13872	/19:25175	/20:44406	/21:51492	/22:110124	/23:98909	/24:556904
/25:748	/26:0	/27:0	/28:0	/29:0	/30:0	/31:0	/32:0

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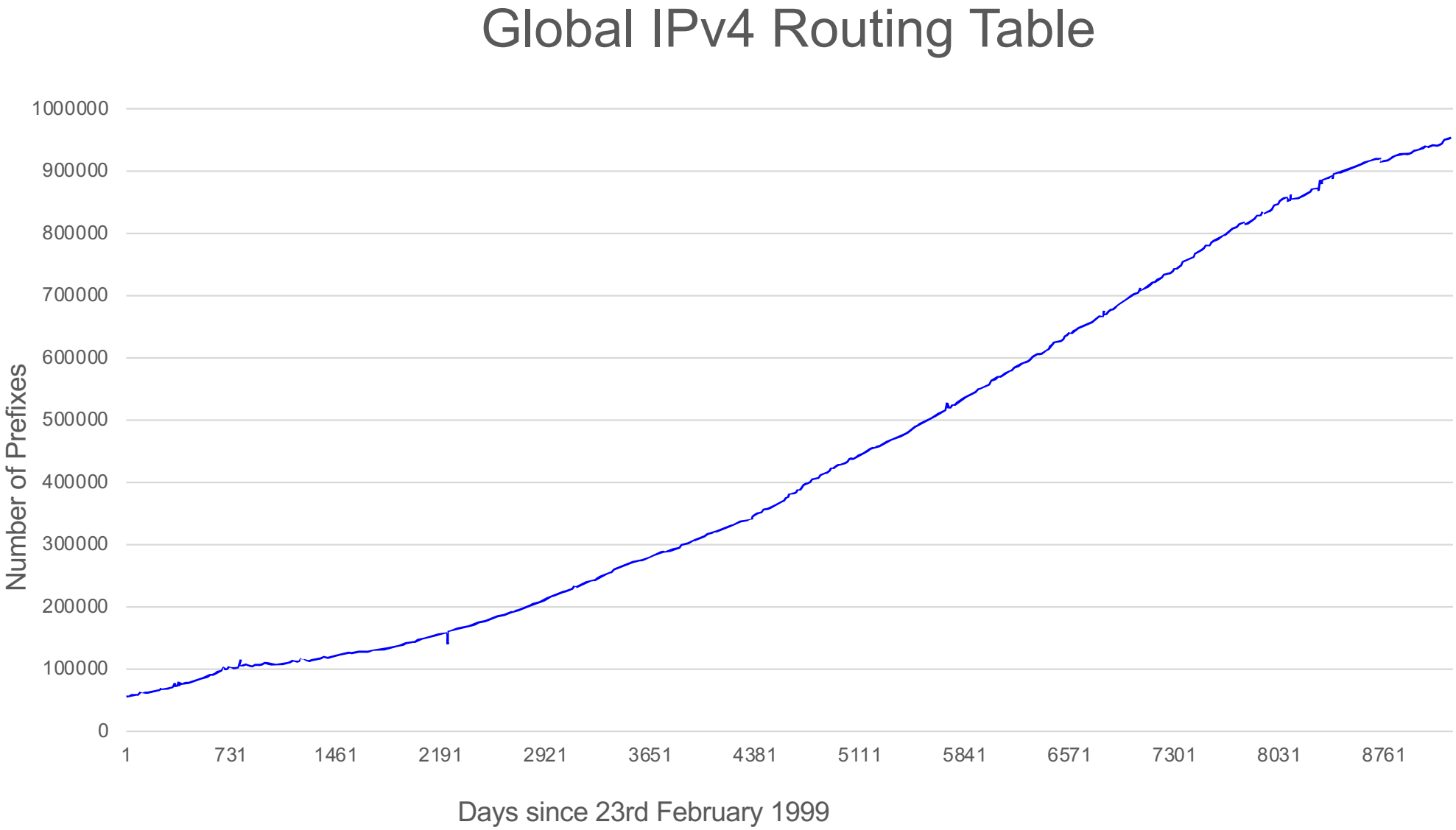
Number of IPv6 prefixes announced by prefix length

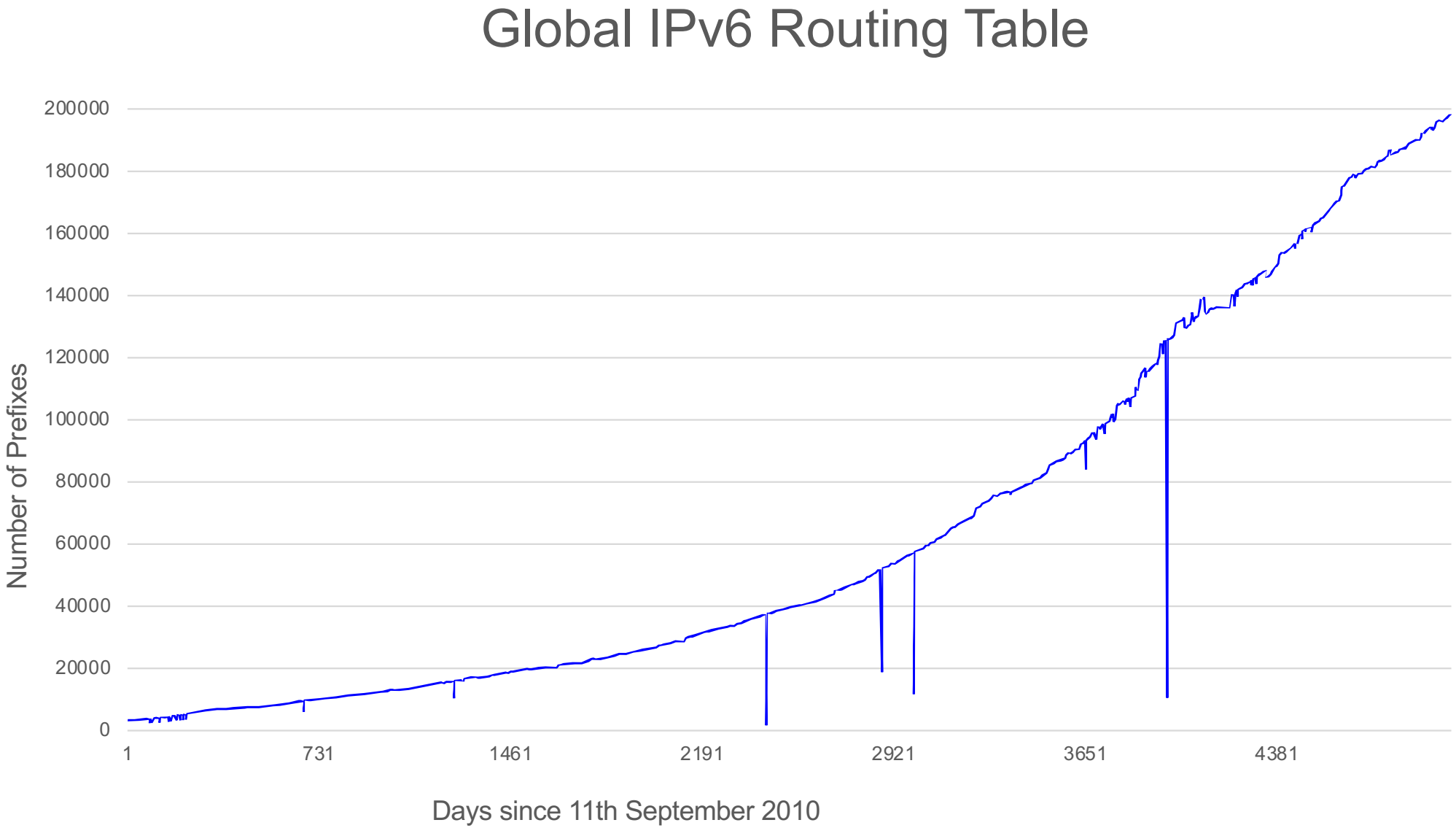
/16:0	/17:0	/18:0	/19:1	/20:13	/21:3	/22:6	/23:8
/24:31	/25:11	/26:16	/27:22	/28:210	/29:5329	/30:616	/31:335
/32:24548	/33:3629	/34:3272	/35:1170	/36:7095	/37:1047	/38:2026	/39:1570
/40:17253	/41:1148	/42:2358	/43:1169	/44:20325	/45:2691	/46:5230	/47:7425
/48:92130	/49:0	/50:0	/51:0	/52:0	/53:0	/54:0	/55:0
/56:0	/57:0	/58:0	/59:0	/60:0	/61:0	/62:0	/63:0
/64:0							

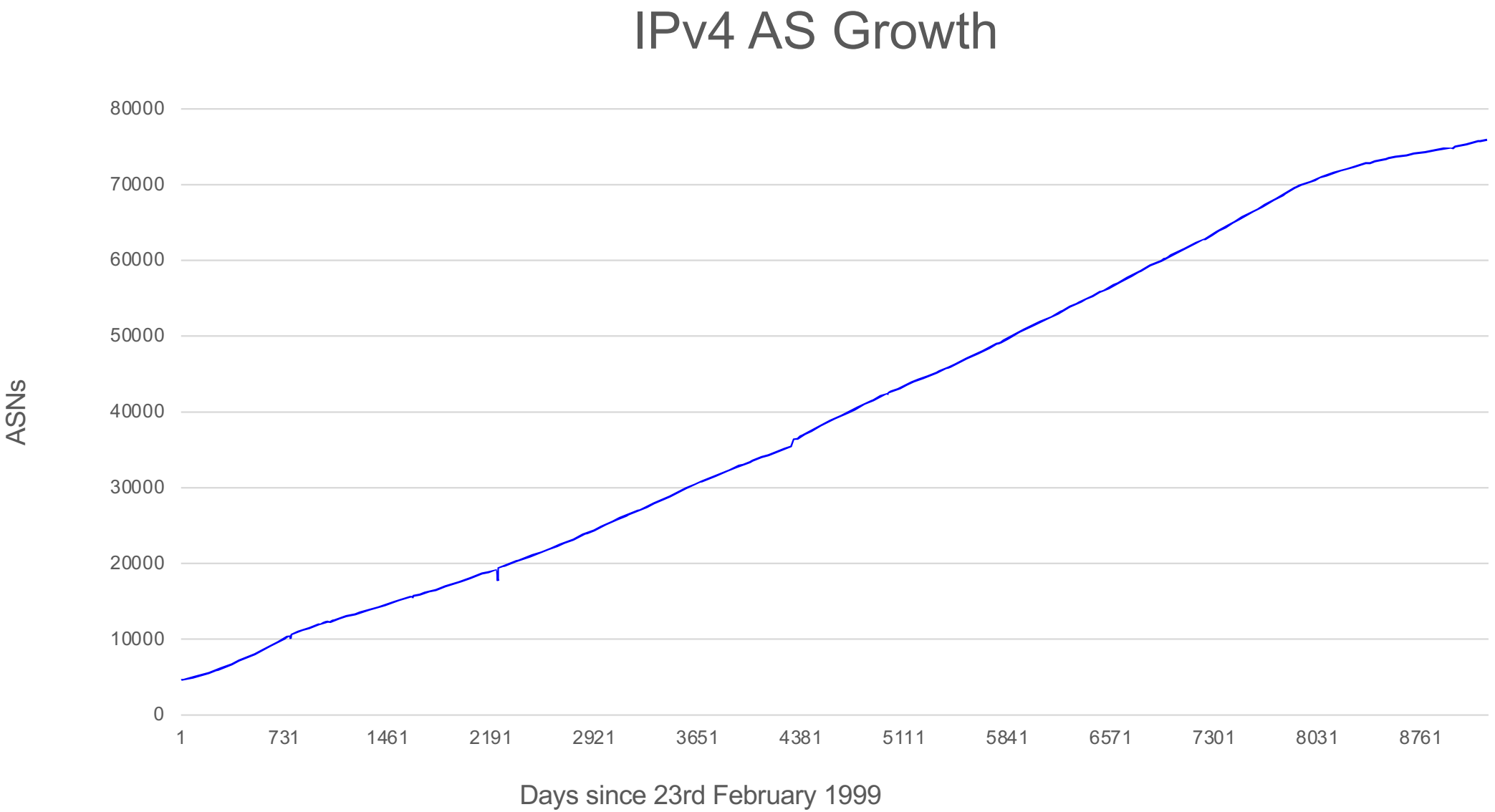
4th August 2024 ↑

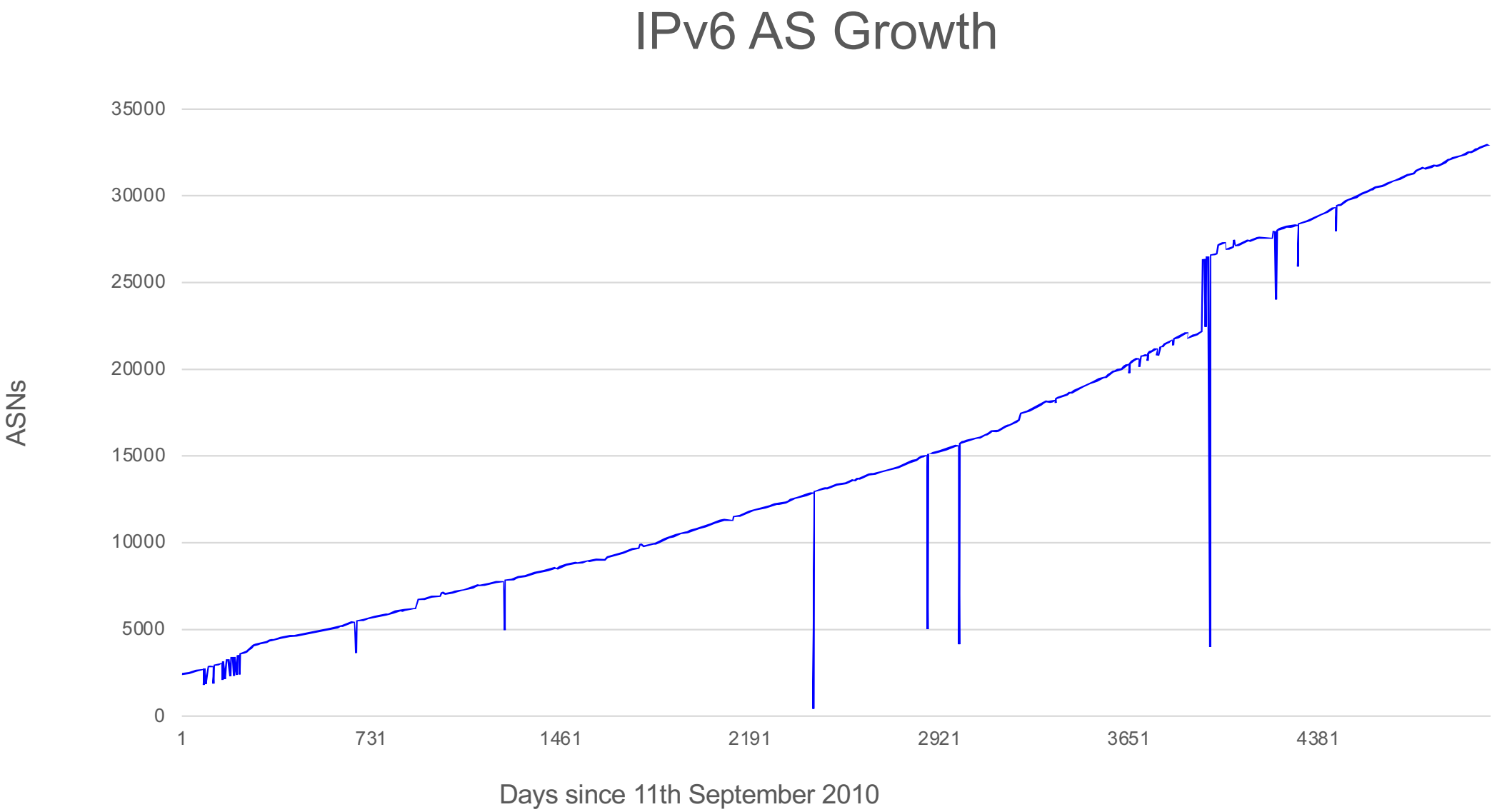
4th August 2023 ↓

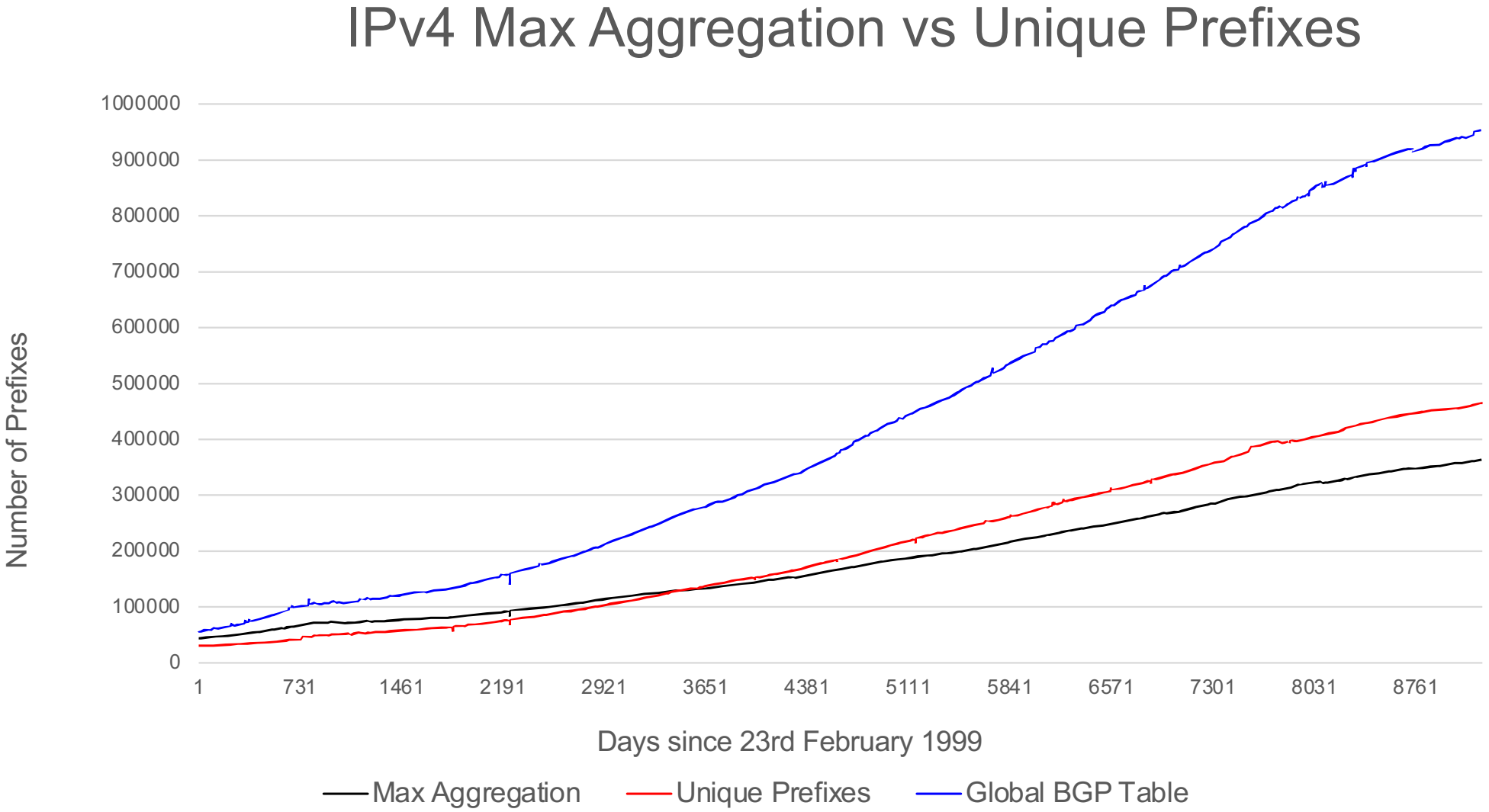
/16:0	/17:0	/18:0	/19:1	/20:14	/21:3	/22:7	/23:7
/24:32	/25:8	/26:16	/27:20	/28:205	/29:4304	/30:605	/31:314
/32:22986	/33:3205	/34:2719	/35:1033	/36:6177	/37:1050	/38:1741	/39:1429
/40:14536	/41:952	/42:3547	/43:1149	/44:17374	/45:2149	/46:4817	/47:5576
/48:83736	/49:0	/50:0	/51:0	/52:0	/53:0	/54:0	/55:0
/56:0	/57:0	/58:0	/59:0	/60:0	/61:0	/62:0	/63:0
/64:2							

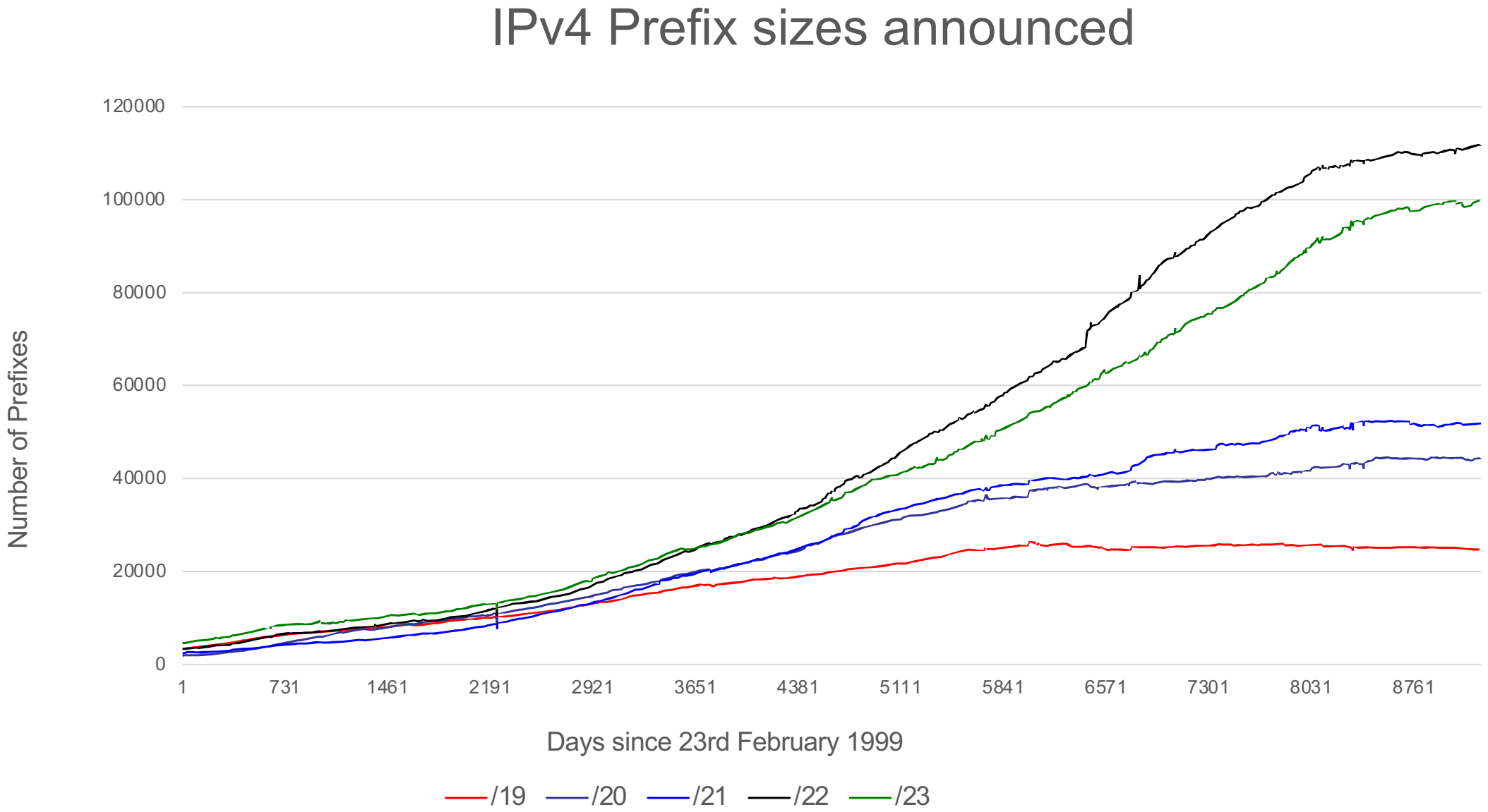

Global IPv4 Routing Table
Number of Prefixes
1000000
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
1
731
1461
2191
2921
3651
4381
5111
5841
6571
7301
8031
8761
Days since 23rd February 1999

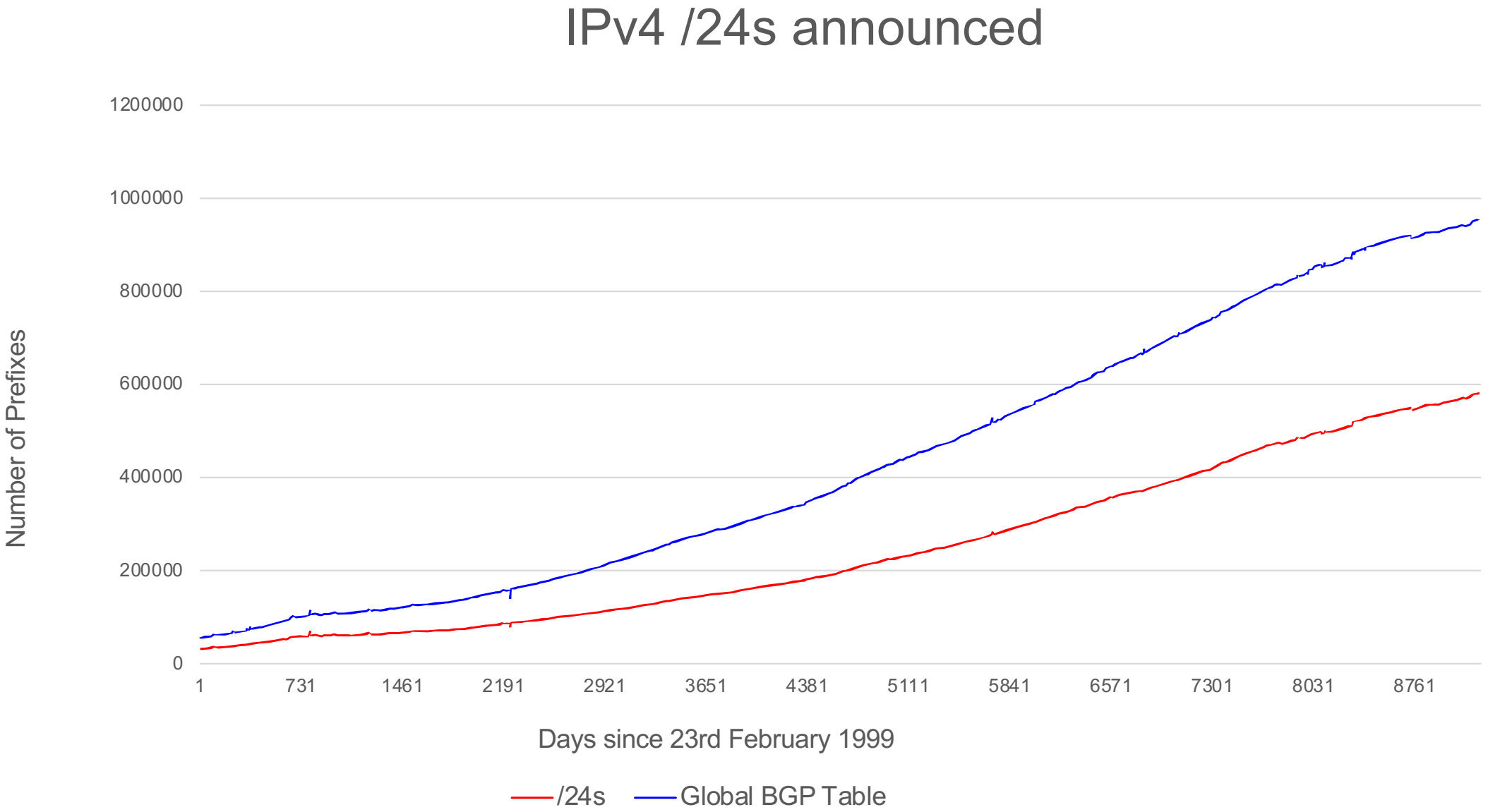

Global IPv6 Routing Table
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Number of Prefixes
1
731
1461
2191
2921
3651
4381
Days since 11th September 2010

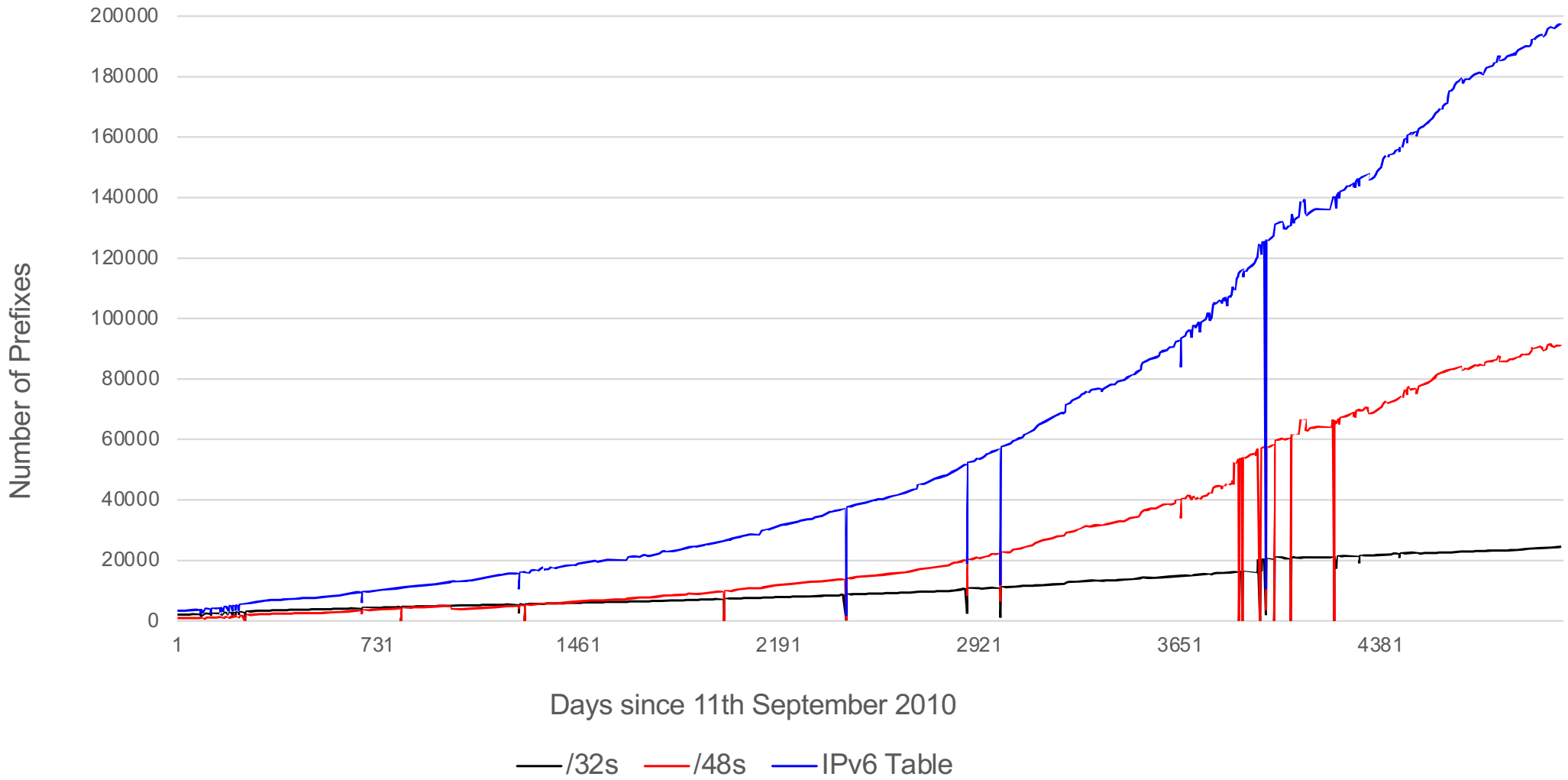

IPv4 AS Growth
ASNs
80000
70000
60000
50000
40000
30000
20000
10000
0
1
731
1461
2191
2921
3651
4381
5111
5841
6571
7301
8031
8761
Days since 23rd February 1999

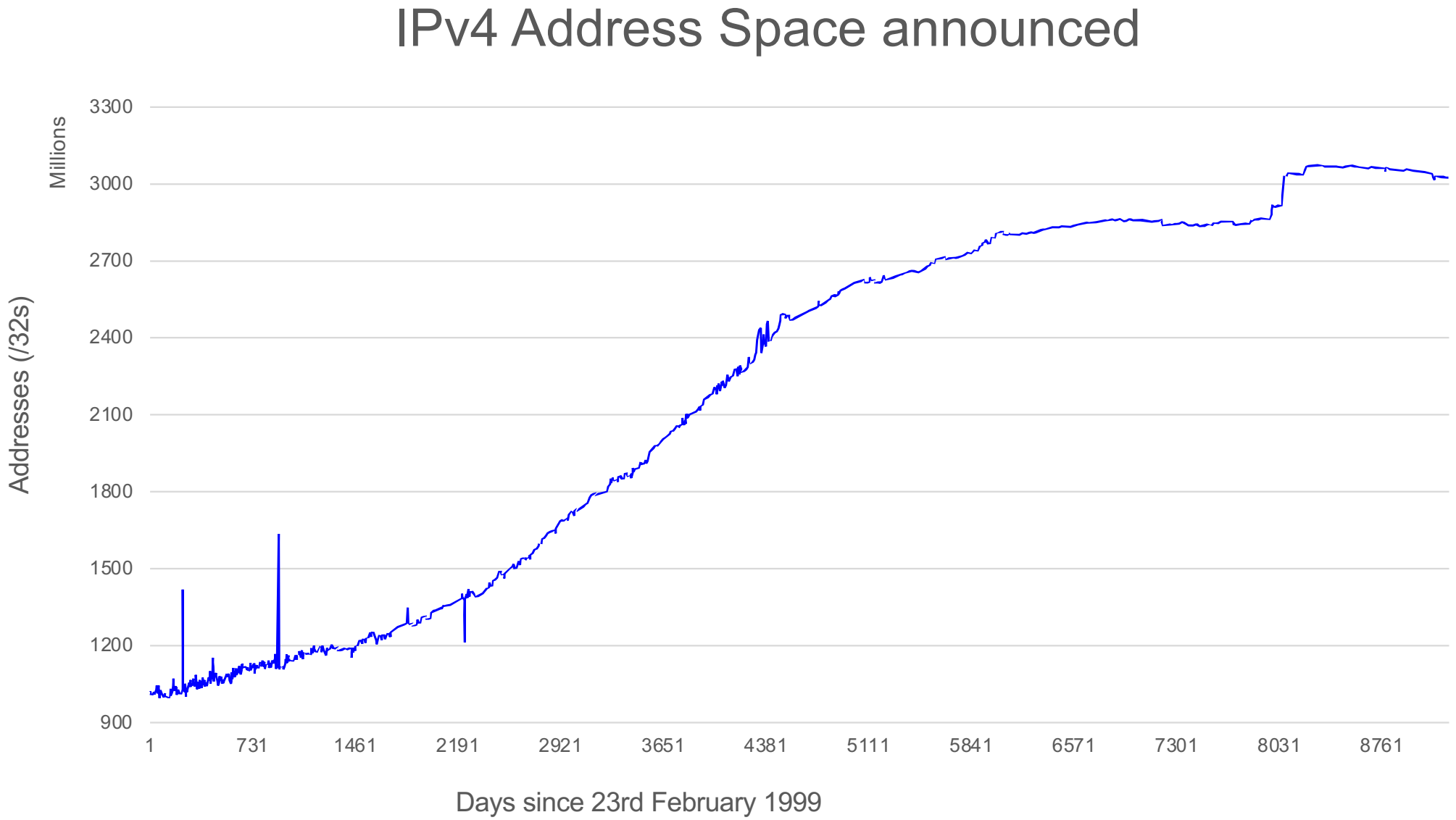

IPv6 AS Growth
35000
30000
25000
20000
15000
10000
5000
0
ASNs
1
731
1461
2191
2921
3651
4381
Days since 11th September 2010

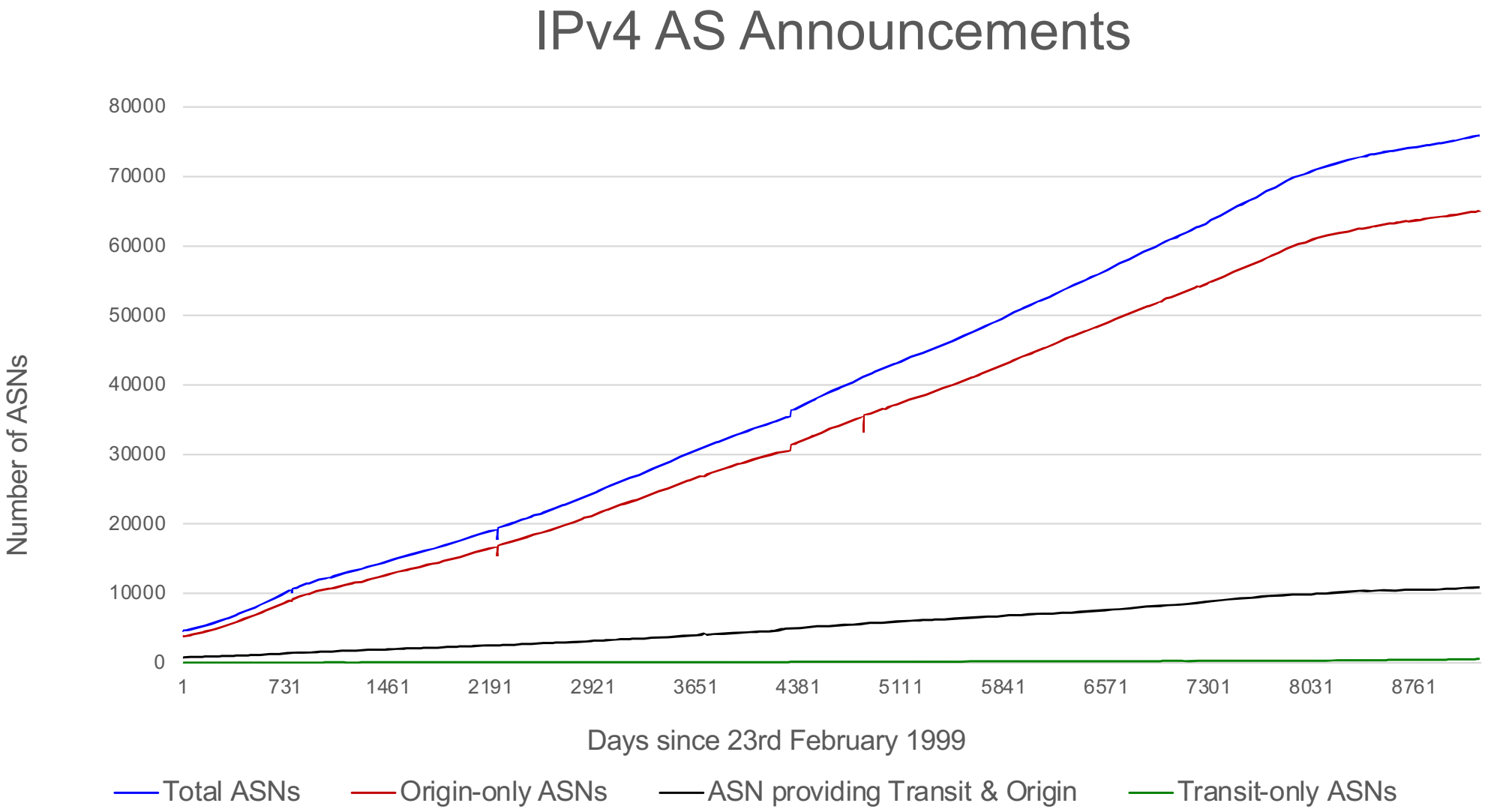

IPv4 Max Aggregation vs Unique Prefixes
Number of Prefixes
1000000
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
1
731
1461
2191
2921
3651
4381
5111
5841
6571
7301
8031
8761
Days since 23rd February 1999
Max Aggregation
Unique Prefixes
Global BGP Table

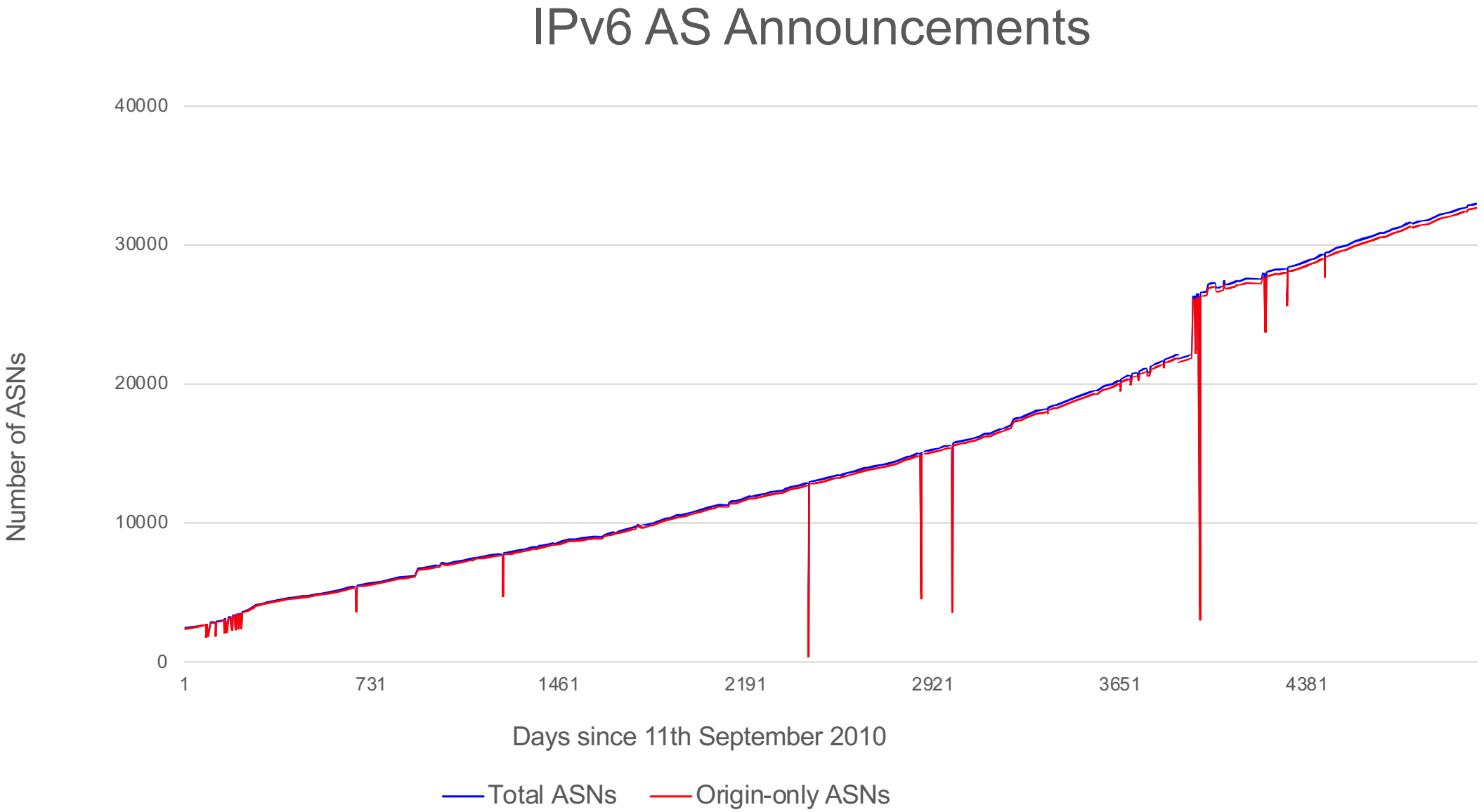

IPv4 Prefix sizes announced
120000
100000
80000
60000
40000
20000
0
Number of Prefixes
1
731
1461
2191
2921
3651
4381
5111
5841
6571
7301
8031
8761
Days since 23rd February 1999
/19
/20
/21
/22
/23

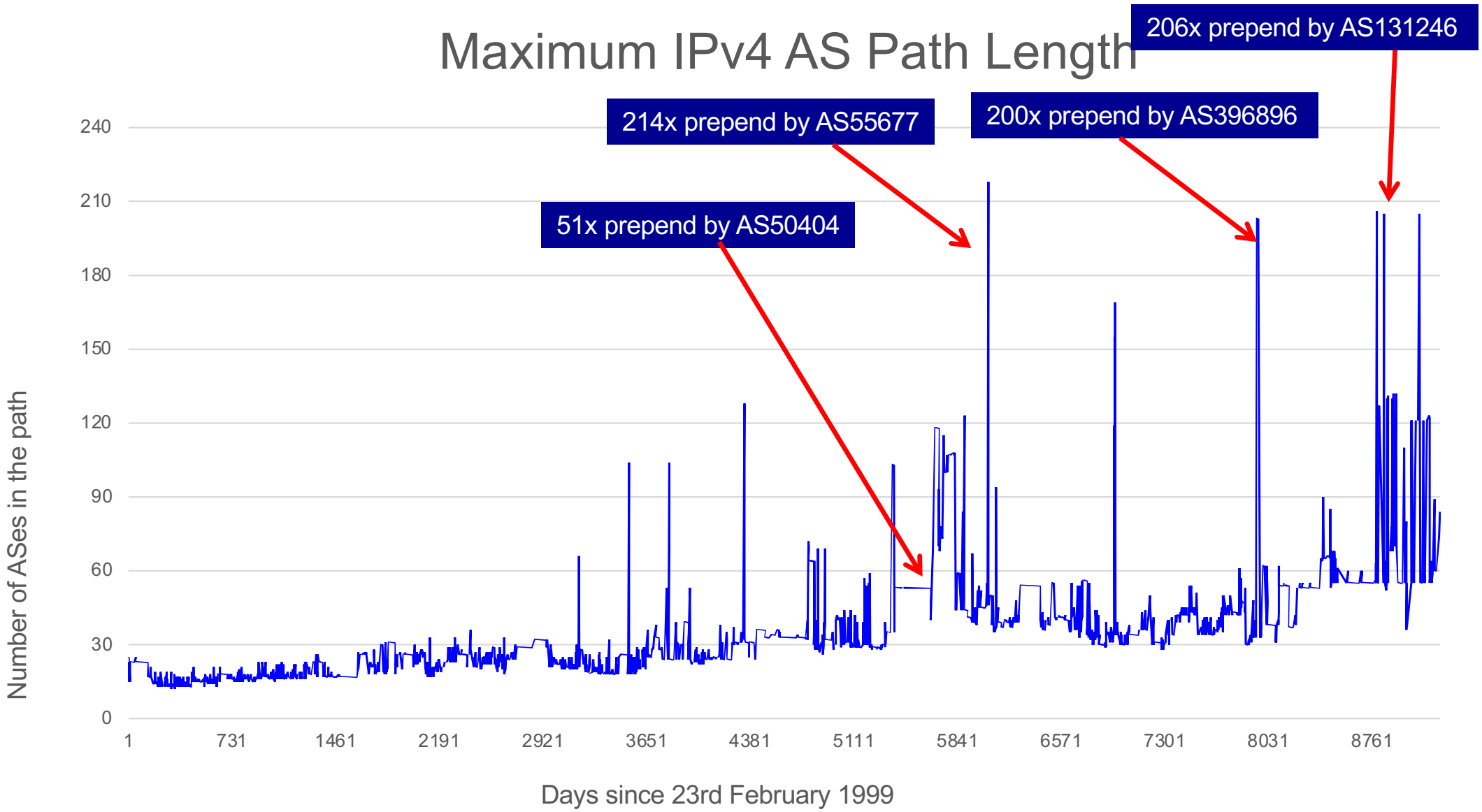

IPv4 /24s announced
1200000
1000000
800000
600000
400000
200000
0
Number of Prefixes
1
731
1461
2191
2921
3651
4381
5111
5841
6571
7301
8031
8761
Days since 23rd February 1999
/24s
Global BGP Table

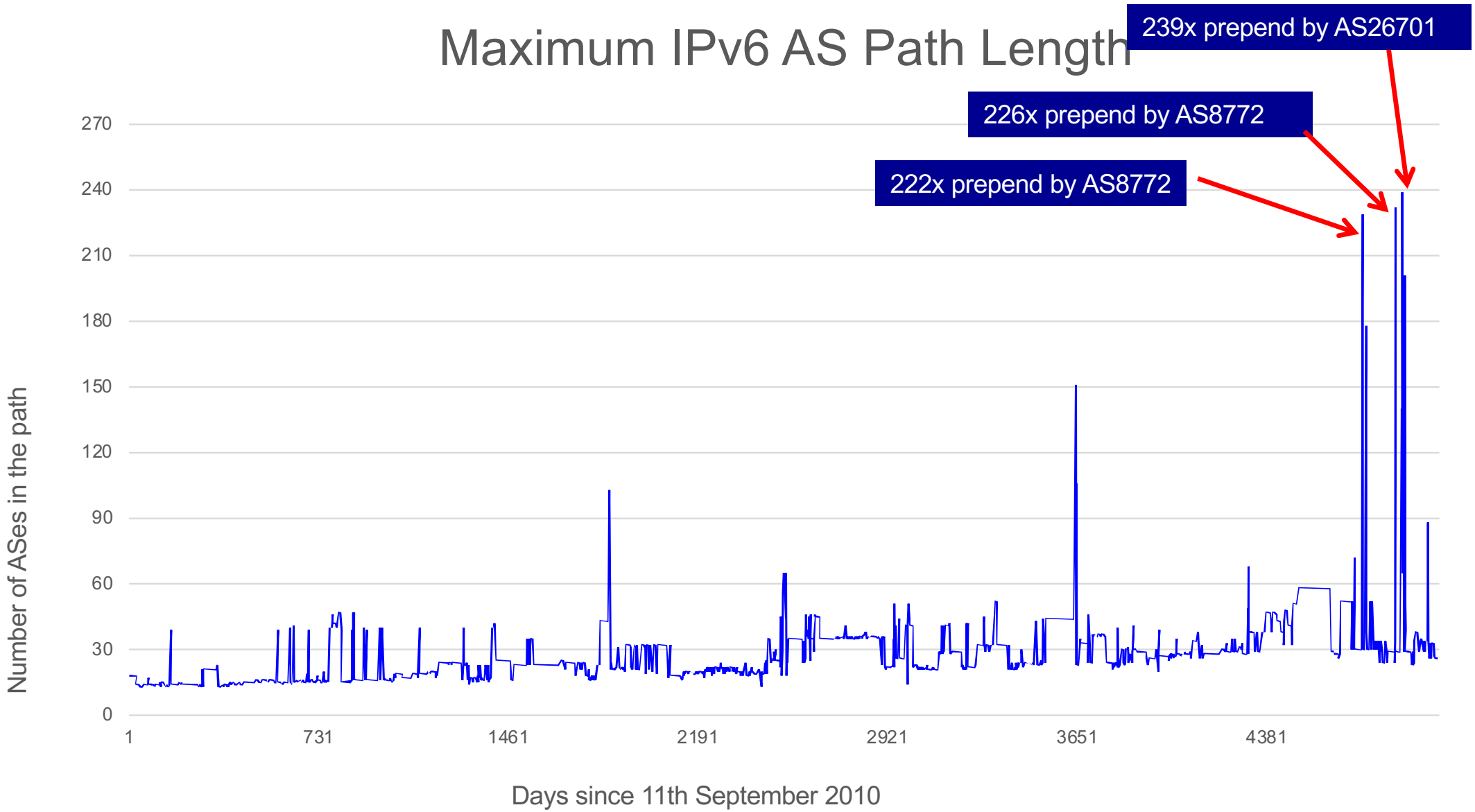

IPv6 /32s vs /48s
Number of Prefixes
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
1
731
1461
2191
2921
3651
4381
Days since 11th September 2010
/32s
/48s
IPv6 Table


IPv4 Address Space announced
Millions
3300
3000
2700
2400
2100
1800
1500
1200
900
Addresses (/32s)
1
731
1461
2191
2921
3651
4381
5111
5841
6571
7301
8031
8761
Days since 23rd February 1999


IPv4 AS Announcements
Number of ASNs
80000
70000
60000
50000
40000
30000
20000
10000
0
1
731
1461
2191
2921
3651
4381
5111
5841
6571
7301
8031
8761
Days since 23rd February 1999
Total ASNs
Origin-only ASNs
ASN providing Transit & Origin
Transit-only ASNs


IPv6 AS Announcements
40000
30000
20000
10000
0
Number of ASNs
1
731
1461
2191
2921
3651
4381
Days since 11th September 2010
Total ASNs
Origin-only ASNs


Maximum IPv4 AS Path Length
206x prepend by AS131246
214x prepend by AS55677
200x prepend by AS396896
51x prepend by AS50404
Number of ASes in the path
240
210
180
150
120
90
60
30
0
1
731
1461
2191
2921
3651
4381
5111
5841
6571
7301
8031
8761
Days since 23rd February 1999


Maximum IPv6 AS Path Length
239x prepend by AS26701
226x prepend by AS8772
222x prepend by AS8772
Number of ASes in the path
270
240
210
180
150
120
90
60
30
0
1
731
1461
2191
2921
3651
4381
Days since 11th September 2010

Looking at Deaggregation in IPv4

- Deaggregation Report
  - One summary takes BGP table and aggregates prefixes by origin AS
    - Called “Max Aggregation” in report
  - Global and per RIR basis
    - https://thyme.apnic.net/
  - For R&E networks worldwide
    - https://bgp.nsrc.org/REN/
  - For ISO-3166 economies
    - https://bgp.nsrc.org/REN/OIX/iso-3166
- Calculates Deaggregation Factor:
  - Measure of Routing Table size/Aggregated Size
  - Global value has been increasing slowly and steadily since “records began”

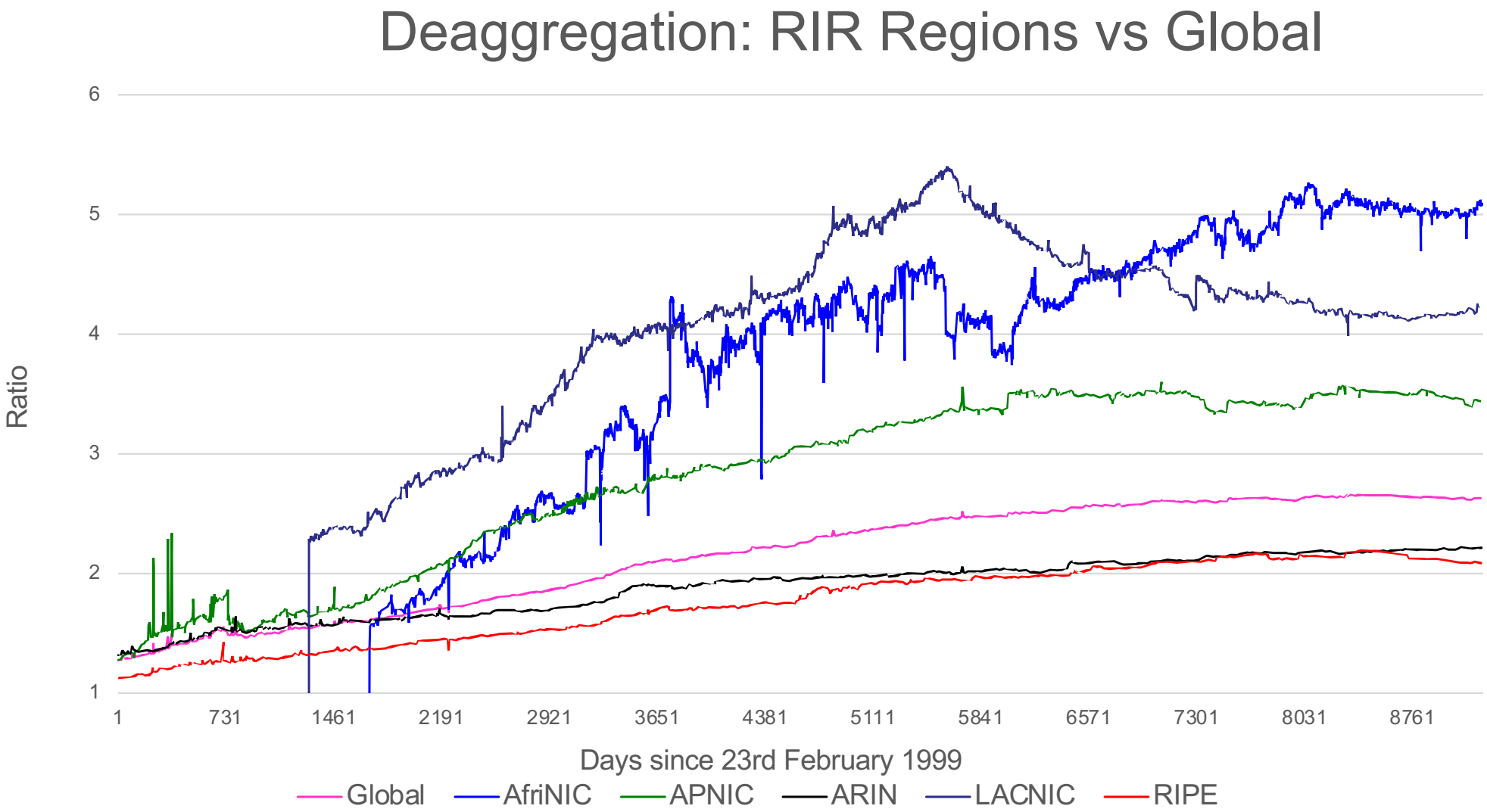
August 2024

Total Prefixes

- Global BGP Table
  - 955k prefixes
- North America
  - 279k prefixes
- Europe & Middle East
  - 266k prefixes
- Asia & Pacific
  - 256k prefixes
- Latin America & Caribbean
  - 122k prefixes
- Africa
  - 31k prefixes

Deaggregation Factor

- Global Average
  - 2.62
- North America
  - 2.22
- Europe & Middle East
  - 2.08
- Asia & Pacific
  - 3.42
- Latin America & Caribbean
  - 4.25
- Africa
  - 5.01


Deaggregation: RIR Regions vs Global
Ratio
6
5
4
3
2
1
1
731
1461
2191
2921
3651
4381
5111
5841
6571
7301
8031
8761
Days since 23rd February 1999
Global
AfriNIC
APNIC
ARIN
LACNIC
RIPE

Asia Pacific Aggregation Savings Summary

ASN	No of Nets	Savings	Description
9808	9869	9790	CHINAMOBILE-CN China Mobile Communications Grou
7545	5662	5000	TPG-INTERNET-AP TPG Telecom Limited, AU
4538	4934	4860	ERX-CERNET-BKB China Education and Research Net
18403	4229	4206	FPT-AS-AP FPT Telecom Company, VN
7552	3965	3944	VIETEL-AS-AP Viettel Group, VN
7713	3638	3572	TELKOMNET-AS-AP PT Telekomunikasi Indonesia, ID
9498	3793	3530	BBIL-AP BHARTI Airtel Ltd., IN
45899	3243	3138	VNPT-AS-VN VNPT Corp, VN
24560	2818	2376	AIRTELBROADBAND-AS-AP Bharti Airtel Ltd., Telem
45090	2188	2109	TENCENT-NET-AP Shenzhen Tencent Computer System
4755	2196	1997	TATACOMM-AS TATA Communications formerly VSNL i
9829	1976	1939	BSNL-NIB National Internet Backbone, IN
23969	1897	1881	TOT-NET TOT Public Company Limited, TH
4766	2274	1700	KIXS-AS-KR Korea Telecom, KR
45609	1861	1546	BHARTI-MOBILITY-AS-AP Bharti Airtel Ltd. AS for
56047	1518	1470	CMNET-HUNAN-AP China Mobile communications corp
56046	1576	1460	CMNET-JIANGSU-AP China Mobile communications co
56041	1518	1447	CMNET-ZHEJIANG-AP China Mobile communications c
9583	1858	1276	SIFY-AS-IN Sify Limited, IN
17557	1235	1201	PKTELECOM-AS-PK Pakistan Telecommunication Comp

https://thyme.apnic.net/current/data-CIDRnet-APNIC

Bhutan Aggregation Savings Summary

ASN	No of nets	/20 equiv	MaxAgg	Description
152317	21	1	4	WPDA-AS-AP Wangdue Phodrang Dzongkhag Adm
134715	13	1	4	GTA-AS-AP Government Technology Agency, B
23955	10	1	4	TASHICELL-DOMESTIC-AS Tashi InfoComm Limi
136039	6	1	2	NANO-AS-AP NANO, Bhutan, BT
18024	6	4	4	BTTELECOM-AS-AP Bhutan Telecom Ltd, BT
135666	5	0	4	MOIC-AS-AP Government Data Center DITTMoi
17660	5	5	4	DRUKNET-AS DrukNet ISP, BT
141680	2	0	1	SUPERNET1-AS-AP SuperNet Infocomm, BT
137994	2	0	2	BNBL-AS-AP Bhutan National Bank limited,
18025	2	0	2	BTTELECOM-AS-AP Bhutan Telecom Ltd, BT
151955	1	0	1	DPBL-AS-AP DRUK PNB BANK LIMITED, BT
151498	1	0	1	BPCL-AS-AP Bhutan Power Corporation Ltd,
140695	1	0	1	BANKOFBHUTAN-AS-AP Bank of Bhutan Limited
138529	1	0	1	DATANET-AS-AP DATANET WIFI, BT
137925	1	0	1	GIC-BHUTAN-AS-AP GIC-Bhutan Reinsurance C
137412	1	0	1	TASHICELL-MOBILE-AS Tashicell Domestic AS
132232	1	0	1	DCS-AS Data Centre Services, BT
38004	1	1	1	FASTLINK-ISP FastLink Wireless ISP, DrukC
7615	1	0	1	BTIX-AS-AP Bhutan Internet Exchange, BT

https://bgp.nsrc.org/REN/OIX/iso-3166/BT-ASnet

Bhutan Address Span Summary

ASN	No of nets	/20 equiv	Description
17660	5	5	DRUKNET-AS DrukNet ISP, BT
18024	6	4	BTTELECOM-AS-AP Bhutan Telecom Ltd, BT
152317	21	1	WPDA-AS-AP Wangdue Phodrang Dzongkhag Administrat
136039	6	1	NANO-AS-AP NANO, Bhutan, BT
134715	13	1	GTA-AS-AP Government Technology Agency, BT
38004	1	1	FASTLINK-ISP FastLink Wireless ISP, DrukCom Pvt.
23955	10	1	TASHICELL-DOMESTIC-AS Tashi InfoComm Limited, BT

https://bgp.nsrc.org/REN/OIX/iso-3166/BT-AS20net

Conclusion

- RouteViews is an incredibly valuable community tool to help network operators and researchers ensure the ongoing stability of the global Internet infrastructure
  - Network Operator network visibility
  - Researchers analysing events, incidents, changes,…
- Global routing table (IPv4 and IPv6) growth shows no sign of abating
  - Deaggregation is the main cause/culprit
  - Every network operator needs to do their part – it's not someone else's problem, it is our collective problem to address

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NSRC
Network Startup Resource Center

THANK YOU

Questions?

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