



Internet Routing Table Analysis Update

Philip Smith

SANOG 40

16th October 2023

Colombo, Sri Lanka



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 from 23rd February 1999:
 - Routing table size
 - CIDR-Report style reporting on a per-RIR basis
 - ...and many other interesting features
- Started recording global IPv6 table in September 2010

IPv4 Routing Report 14th October 2023

BGP routing table entries examined:	932715
Prefixes after maximum aggregation (per Origin AS):	354045
Deaggregation factor:	2.63
Unique aggregates announced (without unneeded subnets):	453796
Total ASes present in the Internet Routing Table:	74910
Prefixes per ASN:	12.45
Origin-only ASes present in the Internet Routing Table:	64286
Origin ASes announcing only one prefix:	26511
Transit ASes present in the Internet Routing Table:	10624
Transit-only ASes present in the Internet Routing Table:	457
Average AS path length visible in the Internet Routing Table:	4.2
Max AS path length visible:	55
Max AS path prepend of ASN (265020)	50
Prefixes from unregistered ASNs in the Routing Table:	991
Number of instances of unregistered ASNs:	994
Special use prefixes present in the Routing Table:	1
Prefixes being announced from unallocated address space:	522
Number of addresses announced to Internet:	3052395776
Equivalent to 181 /8s, 239 /16s and 221 /24s	
Total number of prefixes smaller than registry allocations:	310528

APNIC Region

Prefixes being announced by APNIC Region ASes:	247475
Total APNIC prefixes after maximum aggregation:	71042
APNIC Deaggregation factor:	3.48
Prefixes being announced from the APNIC address blocks:	240913
Unique aggregates announced from the APNIC address blocks:	98990
APNIC Region origin ASes present in the Internet Routing Table:	13684
APNIC Prefixes per ASN:	17.61
APNIC Region origin ASes announcing only one prefix:	4120
APNIC Region transit ASes present in the Internet Routing Table:	1815
Average APNIC Region AS path length visible:	4.4
Max APNIC Region AS path length visible:	24
Number of APNIC addresses announced to Internet:	771669632
Equivalent to 45 /8s, 254 /16s and 190 /24s	
APNIC AS Blocks	4608-4864, 7467-7722, 9216-10239, 17408-18431
(pre-ERX allocations)	23552-24575, 37888-38911, 45056-46079, 55296-56319, 58368-59391, 63488-64098, 64297-64395, 131072-153913
APNIC Address Blocks	1/8, 14/8, 27/8, 36/8, 39/8, 42/8, 43/8, 49/8, 58/8 to 61/8, 101/8, 103/8, 106/8, 110/8 to 126/8, 133/8, 175/8, 180/8, 182/8, 183/8, 202/8, 203/8, 210/8, 211/8, 218/8 to 223/8

Global per AS IPv4 prefix count summary

ASN	No of nets	/20 equiv	Max Agg	Description
8151	11852	3378	601	UNINET, MX
9808	9498	8730	43	CHINAMOBILE-CN China Mobile Communicati
16509	9188	11009	3251	AMAZON-02, US
12479	7397	1713	145	UNI2-AS, ES
7545	5714	785	698	TPG-INTERNET-AP TPG Telecom Limited, AU
4538	4941	4192	75	ERX-CERNET-BKB China Education and Rese
39891	4897	290	61	ALJAWWALSTC-AS, SA
11492	4538	301	671	CABLEONE, US
18403	4210	347	25	FPT-AS-AP FPT Telecom Company, VN
7155	4172	288	100	VIASAT-SP-BACKBONE, US
20940	4093	3398	153	AKAMAI-ASN1, NL
7713	3596	1043	63	TELKOMNET-AS-AP PT Telekomunikasi Indon
6327	3546	1319	66	SHAW, CA
10620	3538	504	860	Telmex Colombia S.A., CO
22773	3525	3055	300	ASN-CXA-ALL-CCI-22773-RDC, US
8551	3448	368	34	BEZEQ-INTERNATIONAL-AS Bezeqint Interne
45899	3327	1840	96	VNPT-AS-VN VNPT Corp, VN
9498	3211	495	249	BBIL-AP BHARTI Airtel Ltd., IN
749	3161	54958	2413	DNIC-AS-00749, US
367	3077	3857	1441	DNIC-ASBLK-00306-00371, US

AfrINIC APNIC ARIN LACNIC RIPE NCC



What about IPv6 ?

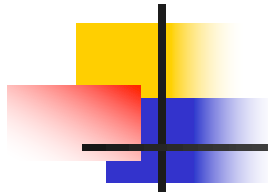
IPv6 Routing Report 15th October 2023 (London)

BGP routing table entries examined:	183306
Number of IPv6 prefixes with a valid ROA:	101585
Number of IPv6 prefixes with an invalid ROA:	644
Number of IPv6 prefixes with no ROA:	81077
Total ASNs present in the IPv6 Routing Table:	31580
Average AS path length:	4.6
Longest AS path:	52
Total Origin ASNs present in the IPv6 Routing Table:	31279
Paths with bogon ASNs present in the IPv6 Routing Table:	8

Global IPv6 per AS prefix count summary (London)

ASN	No of Nets	Description
11172	6164	Alestra, S. de R.L. de C.V., MX
9808	4543	CHINAMOBILE-CN China Mobile Communications Group Co., Ltd.,
18403	4275	FPT-AS-AP FPT Telecom Company, VN
16509	4127	AMAZON-02, US
7552	2523	VIETEL-AS-AP Viettel Group, VN
45609	2510	BHARTI-MOBILITY-AS-AP Bharti Airtel Ltd. AS for GPRS Service
24547	1850	CMNET-V4HEBEI-AS-AP Hebei Mobile Communication Company Limit
45271	1808	ICLNET-AS-AP Idea Cellular Limited, IN
12479	1634	UNI2-AS, ES
5416	1545	Internet Service Provider, BH
17622	1533	CNCGROUP-GZ China Unicom Guangzhou network, CN
28573	1475	Claro NXT Telecomunicacoes Ltda, BR
38266	1442	VIL-AS-AP Vodafone Idea Ltd, IN
32098	1438	TRANSTELCO-INC, US
36183	1386	AKAMAI-AS, US
13335	1315	CLOUDFLARENET, US
17072	1312	TOTAL PLAY TELECOMUNICACIONES SA DE CV, MX
39891	1204	ALJAWWALSTC-AS, SA
22773	1200	ASN-CXA-ALL-CCI-22773-RDC, US
56046	1145	CMNET-JIANGSU-AP China Mobile communications corporation, CN

AfriNIC APNIC ARIN LACNIC RIPE NCC

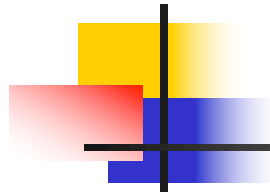


IPv6 deaggregation – Alestra (May)

```
Network Path
v*> 2001:1248:1::/48 6453 1299 11172 i
v*> 2001:1248:2::/48 6453 3491 11172 i
v*> 2001:1248:3::/48 6453 1299 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 i
v*> 2001:1248:4::/48 6453 1299 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 i
v*> 2001:1248:3000::/42 6453 1299 11172 i
v*> 2001:1248:3001::/48 6453 1299 11172 i
v*> 2001:1248:3002::/48 6453 1299 11172 i
...
v*> 2001:1248:88fc::/48 6453 1299 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 i
v*> 2001:1248:88fd::/48 6453 1299 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 i
v*> 2001:1248:88fe::/48 6453 1299 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 i
...
v*> 2001:1248:ab40::/42 6453 1299 11172 i
v*> 2001:1248:ab80::/42 6453 1299 11172 i
v*> 2001:1248:abc0::/42 6453 1299 11172 i
v*> 2001:1248:ad00::/42 6453 174 11172 i
v*> 2001:1248:ad28::/48 6453 1299 11172 i
v*> 2001:1248:b0a1::/48 6453 1299 11172 I
```

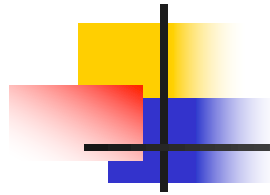
Points to Ponder:

1. there are 65536 /48s in a /32
2. No announcement of covering /32
3. 9x prepend doing nothing!
4. What "traffic engineering" ?



IPv6 deaggregation – Alestra (October)

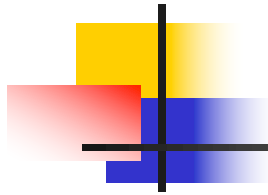
```
Network Path
v*> 2001:1248:1::/48 1299 11172 i
v*> 2001:1248:2::/48 2914 3491 11172 i
v*> 2001:1248:3::/48 1299 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 i
v*> 2001:1248:4::/48 1299 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 i
v*> 2001:1248:3000::/42 1299 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 i
v*> 2001:1248:3001::/48 1299 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 i
v*> 2001:1248:3002::/48 1299 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 I
...
v*> 2001:1248:88fc::/48 1299 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 i
v*> 2001:1248:88fd::/48 1299 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 i
v*> 2001:1248:88fe::/48 1299 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 I
...
v*> 2001:1248:ab40::/42 1299 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 i
v*> 2001:1248:ab80::/42 1299 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 i
v*> 2001:1248:abc0::/42 1299 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 i
v*> 2001:1248:ac00::/42 2914 174 11172 ?
v*> 2001:1248:ac04::/48 2914 6453 32098 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 ?
v*> 2001:1248:ac05::/48 1299 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 11172 i
```



IPv6 deaggregation – Dialog (LK)

Network	Path
V*> 2402:4000::/32	6939 45489 18001 i
V*> 2402:4000:1080::/48	6939 45489 18001 i
V*> 2402:4000:1081::/48	6939 45489 18001 i
V*> 2402:4000:1082::/48	6939 45489 18001 i
V*> 2402:4000:1083::/48	6939 45489 18001 i
V*> 2402:4000:1084::/48	6939 45489 18001 i
V*> 2402:4000:1085::/48	6939 45489 18001 i
V*> 2402:4000:1086::/48	6939 45489 18001 i
V*> 2402:4000:1087::/48	6939 45489 18001 i
V*> 2402:4000:10c0::/48	6939 45489 18001 i
V*> 2402:4000:10c1::/48	6939 45489 18001 i
V*> 2402:4000:10c2::/48	6939 45489 18001 i
V*> 2402:4000:10c3::/48	6939 45489 18001 i
V*> 2402:4000:10c4::/48	6939 45489 18001 i
V*> 2402:4000:10c5::/48	6939 45489 18001 I
V*> 2402:4000:10c6::/48	6939 45489 18001 i
V*> 2402:4000:10c7::/48	6939 45489 18001 i
V*> 2402:4000:10c8::/48	6939 45489 18001 i
V*> 2402:4000:10c9::/48	6939 45489 18001 i

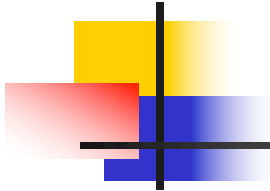
Why?



IPv6 deaggregation – SLT (LK)

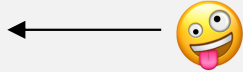
Network	Path
V*> 2402:d000::/32	6939 45489 9329 i
V*> 2402:d000:20::/48	6939 45489 9329 i
V*> 2402:d000:21::/48	6939 45489 9329 i
V*> 2402:d000:140::/48	6939 45489 9329 i
V*> 2402:d000:141::/48	6939 45489 9329 i
V*> 2402:d000:142::/48	6939 45489 9329 i
V*> 2402:d000:100c::/48	6939 45489 9329 i
V*> 2402:d000:7000::/48	6939 45489 9329 i
V*> 2402:d000:8100::/48	6939 45489 9329 i
V*> 2402:d000:8104::/48	6939 45489 9329 i
V*> 2402:d000:8108::/48	6939 45489 9329 i
V*> 2402:d000:810c::/48	6939 45489 9329 i
V*> 2402:d000:8110::/48	6939 45489 9329 i
V*> 2402:d000:8114::/48	6939 45489 9329 i
V*> 2402:d000:8118::/48	6939 45489 9329 i
V*> 2402:d000:8120::/48	6939 45489 9329 I
V*> 2402:d000:8124::/48	6939 45489 9329 i
V*> 2402:d000:8128::/48	6939 45489 9329 i
V*> 2402:d000:812c::/48	6939 45489 9329 i

Why?



Non-routable ASNs for IPv4

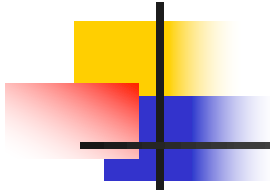
Network	Path
V*> 46.221.6.0/24	6453 1273 15924 65989
N*> 102.221.75.0/24	6453 9498 327708 327708 327708 327708 327708 327708 36873 36873 761467
N*> 103.20.204.0/22	24482 45430 134240 {45458,65000,134240}
N*> 103.88.68.0/23	9304 17639 132505 64920 132505 132505 132505 132505 132505 132505 132505 132505 132505
N*> 103.117.81.0/24	45352 65533 55855
I*> 103.162.26.0/24	9930 65379
V*> 103.224.48.0/24	9583 134922 134922 1342922 134922 134922 134922
V*> 103.224.54.0/24	9583 134922 134922 1342922 134922 134922 134922
N*> 121.52.203.0/24	45352 65533 55855
N*> 164.115.9.0/24	4651 9835 65200 66669 64794 65100
N*> 164.115.15.0/24	4651 9835 65200 66669 64794 65100
N*> 164.115.251.0/24	4651 38450 38450 38450 66666 66666
V*> 193.22.254.0/24	6453 3320 15830 200346 200346 2000346 200346
I*> 202.185.181.0/24	9930 65295
I*> 202.185.188.0/24	9930 65295
I*> 211.24.36.0/24	9930 65206
I*> 211.25.111.0/24	9930 65206
I*> 211.25.240.0/22	9930 65295
I*> 211.25.244.0/22	9930 65295
N*> 213.172.134.0/24	6453 3356 37271 328471 328471 328471 420000803
N*> 213.172.146.0/24	6453 3356 37271 328471 328471 328471 420000203
N*> 213.172.147.0/24	6453 3257 37271 328471 328471 328471 420000403
N*> 213.172.149.0/24	6453 174 30844 328471 328471 328471 420000603



Documentation ASN

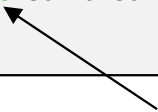
IANA Reserved ASN

Private ASN



Non-routable ASNs for IPv6

Network	Path
N*> 2001:948::/29	2603 {224,39590,64530,64540,64541,64565,65002,65003,65004,65005,65006,65007,65008,65009,65010,65011,65430}
I*> 2001:f40:11::/48	9930 65206
V*> 2620:131:3009::/48	6453 4755 58419 58419 58419 58419 58419 58419 58419 58419 58419 58419
N*> 2801:19:c800::/48	6453 174 13489 64500
N*> 2a0c:a641::/32	6453 3257 8781 42298 65540



Documentation ASN

IANA Reserved ASN

Private ASN



Deprecated AS Set

- Use of BGP AS Set is not recommended
 - RFC6472/BCP172 (December 2011)
- There are still some in both IPv4 and IPv6 BGP tables
 - IPv4 has 259 entries
 - IPv6 has 30 entries

IPv4 Prefixes using Deprecated AS_SET

Net Originated	AS Path
5.180.210.0/24	3257 62240 62240 {62240}
8.41.202.0/24	13789 13789 13789 13789 13789 13789 13789 13789 13789 30372 {40179}
15.36.64.0/18	2687 25888 {21326}
20.137.0.0/21	3356 21877 {4237}
20.137.160.0/20	3356 206 {4237}
20.137.176.0/20	3356 21877 {4237}
20.137.240.0/20	3356 21877 {4237}
23.56.208.0/24	1299 20940 {12222}
23.200.20.0/24	3257 20940 20940 {12222}
23.217.64.0/19	1299 8151 20940 20940 {16625}
24.49.144.0/20	3257 22646 {400511}
27.71.16.0/21	4637 7552 {38731}
37.52.0.0/14	1299 6849 {6877}
37.221.128.0/19	3257 3255 {62384}
38.51.148.0/22	1299 12956 53764 53764 53764 {21559,398317}
41.215.160.0/20	6762 37613 37030 {37140}
41.215.160.0/21	6762 37613 37030 37030 37030 37030 {37140}
41.215.162.0/24	6762 37613 37030 {37140}
41.215.168.0/21	6762 37613 37030 {37140}
46.200.0.0/14	1299 6849 {6877}
...	
213.186.96.0/19	1299 6849 {6877}
213.255.226.0	1299 62240 62240 62240 {62240}
216.16.208.0/20	3257 22646 {400511}
216.110.102.0	3491 23520 14813 {11139}
216.126.96.0/20	577 22573 {6058}
216.183.128.0/19	174 19752 11727 {62865}
216.221.208.0/22	3356 26585 26585 {26585}
216.221.212.0/22	3356 26585 26585 {26585}
216.221.220.0/22	3356 26585 26585 {26585}
216.241.10.0	6461 52320 52468 52468 52468 18747 {52411}
217.24.112.0/20	12389 {28860}
217.25.32.0/20	2119 25146 {41943}
217.27.240.0/20	1299 2914 29006 {36483}
217.65.248.0/21	174 3255 {59671}
217.112.32.0/20	1273 3216 30943 {40966}
217.168.16.0/20	1299 2914 29006 {36483}

IPv6 Prefixes using Deprecated AS_SET

Net Originated	AS Path
2001:510::/32	3257 376 {36786}
2001:678:16::/48	12389 45029 42385 {20764,42385,43832}
2001:678:6d0::/48	3216 212748 {212748}
2001:6d0:ffd5::/48	12389 45029 42385 {8359,20764,42139,42385}
2001:4220::/32	1273 24835 {36935}
2001:4220::/33	1273 24835 {36935}
2402:4640::/33	4788 38044 {23736}
2402:4640:8000::/33	4788 38044 {23736}
2402:7500::/32	3491 9924 {24158}
2402:8100::/32	3491 55644 {36040,38266,45271,55410}
2403:8400::/48	9498 17917 {36040}
2404:c000::/32	7473 45147 {16625,17727,55818}
2404:c000::/33	7473 45147 {16625,55818}
2606:b400:8814::/48	3356 7160 {7160}
2607:f280::/32	174 14615 {398053}
2607:f390::/32	3257 32440 {2055,17244}
2607:f7a8:600::/39	3257 46887 {397488}
2607:f7a8:800::/39	3257 46887 {395749}
2607:f7a8:c00::/39	3257 46887 {21687}
2620:1b2::/36	16735 26673 {64966}
2620:1b2:cb0::/44	16735 26673 {64966}
2800:480::/32	6453 14080 14080 14080 14080 {10620,264718}
2800:486::/32	6453 14080 {10620}
2a00:6480::/32	3320 35548 35548 35548 35548 {29018}
2a02:6680:1::/48	174 8551 16116 {211612}
2a09:bd00::/48	12389 45029 42385 {20764,42385,43832}
2a0a:39c0::/32	1299 62240 {62240}
2a0a:bcc0::/29	2603 1653 41001 {64600,65001,65002,65501,65502}
2a0e:b2c4::/30	3216 212748 {212748}
2a0e:b800::/31	3257 31287 197216 {6939,20473}



Unassigned resources

- Use of unassigned address space is rampant
 - Currently 522 unassigned prefixes in IPv4 routing table
- Use of unassigned ASNs is also a big problem
 - Currently 397 unassigned ASNs in use
- Many are transited by well-known / reputable operators
 - Why??

List of Unregistered Origin ASNs

The complete list in use:

940, 1636, 1782, 4879, 6081, 6485, 6565, 7064, 7257, 7607, 10425, 10475, 10981, 11011, 11044, 11091, 11223,
11316, 11490, 11593, 11610, 11636, 11819, 11945, 12109, 12169, 12176, 12240, 13224, 13339, 13342, 13492, 13920,
13980, 14015, 14076, 14167, 14350, 14428, 14461, 14545, 14605, 14651, 14736, 14889, 15178, 15200, 15220, 15238,
15249, 15804, 16615, 16666, 16769, 16804, 16860, 17341, 18586, 18691, 18781, 18799, 18805, 18821, 18976, 19081,
19140, 19142, 19176, 19359, 19507, 19533, 19708, 19926, 19987, 20118, 20190, 20200, 20227, 20380, 20421, 20443,
21649, 21695, 21861, 21942, 21986, 22160, 22271, 22272, 22484, 22538, 22539, 22694, 22698, 22733, 22736, 22774,
22778, 22830, 23021, 23176, 23190, 23194, 23262, 23288, 23357, 23411, 23448, 23507, 23658, 23985, 25568, 25600,
25641, 25647, 25786, 25800, 25823, 25831, 25978, 26016, 26018, 26140, 26171, 26286, 26295, 26345, 26377, 26443,
26520, 26643, 26682, 26701, 26712, 26758, 26759, 26799, 26861, 26961, 26986, 27174, 27180, 27247, 27284, 27289,
27291, 27335, 27361, 27426, 27470, 27593, 29763, 29782, 29829, 29855, 30004, 30037, 30104, 30155, 30218, 30426,
30442, 30550, 30699, 31781, 31813, 32094, 32103, 32121, 32187, 32282, 32346, 32358, 32497, 32534, 32596, 32772,
32801, 32916, 33017, 33027, 33051, 33123, 33137, 33232, 33245, 33394, 33417, 33484, 33492, 33625, 33684, 35941,
36002, 36045, 36077, 36264, 36267, 36283, 36357, 36465, 36679, 36774, 36893, 36900, 36928, 36979, 37103, 37155,
37162, 37169, 37320, 37338, 37442, 37475, 37476, 37544, 37591, 37703, 38055, 39991, 40186, 40255, 40279, 40493,
40600, 40687, 40726, 40751, 40804, 40909, 40920, 46086, 46123, 46226, 46228, 46233, 46472, 46559, 46673, 46772,
46815, 46876, 46916, 47044, 47086, 53059, 53298, 53367, 53419, 53552, 53657, 53715, 53771, 53775, 53786, 53854,
53886, 53929, 53947, 54215, 54231, 54278, 54338, 54424, 54776, 54787, 55084, 55227, 55289, 59955, 62641, 62770,
62801, 62820, 62828, 63092, 63125, 63190, 63198, 63248, 63305, 63387, 63401, 63433, 64011, 64203, 64235, 64339,
65539, DOC 65540, DOC 65555, 65646, 65777, 65778, 65989, 66666, 84565, 132172, 134182, 137871, 138032, 138918,
139053, 139060, 140664, 140712, 141452, 147295, 149486, 149866, 150154, 208694, 227171, 230105, 256484, 262509,
262692, 262745, 262992, 264493, 265039, 266974, 267371, 268152, 268652, 269313, 270345, 271123, 271675, 271724,
327869, 327933, 328007, 328149, 328226, 328248, 328369, 328771, 393218, 393266, 393305, 393314, 393320, 393377,
393446, 393476, 393587, 393808, 394076, 394156, 394293, 394402, 394519, 394607, 394721, 394754, 394787, 394788,
394839, 394879, 394936, 394939, 395270, 395282, 395350, 395376, 395377, 395438, 395514, 395522, 395556, 395557,
396015, 396314, 396330, 396451, 396831, 396894, 396993, 397327, 397607, 397658, 398118, 398829, 399382, 399572,
399618, 400352, 761467, 2694927, 420000203, 420000403, 420000603, 420000803, 4200000116, 4260233229

List of Unregistered Origin ASNs

Far too many to list. See <http://thyme.apnic.net/current/data-badAS>:

Bad AS	Designation	Net Originated	Transit AS	Transit AS Name
33123	UNALLOCATED	8.10.69.0/24	11168	SCC, US
12169	UNALLOCATED	8.15.207.0/24	32787	PROLEXIC-TECHNOLOGIES-DDOS-M
40493	UNALLOCATED	8.17.26.0/24	3356	LEVEL3, US
53775	UNALLOCATED	8.20.88.0/24	7029	WINDSTREAM, US
62828	UNALLOCATED	8.21.130.0/24	3356	LEVEL3, US
393266	UNALLOCATED	8.23.52.0/24	46887	LIGHTTOWER, US
396894	UNALLOCATED	8.28.201.0/24	46887	LIGHTTOWER, US
394936	UNALLOCATED	8.33.224.0/24	22442	HOU-PHONOSCOPE, US
54338	UNALLOCATED	8.33.241.0/24	6461	ZAYO-6461, US
1782	UNALLOCATED	8.42.19.0/24	3356	LEVEL3, US
395438	UNALLOCATED	8.42.206.0/24	3356	LEVEL3, US
396451	UNALLOCATED	12.6.254.0/24	7018	ATT-INTERNET4, US
13342	UNALLOCATED	12.17.5.0/24	7018	ATT-INTERNET4, US
26345	UNALLOCATED	12.21.93.0/24	40264	TWC-40264-WI-MN-UPPERMI-C3,
396831	UNALLOCATED	12.23.198.0/24	33491	COMCAST-33491, US
21861	UNALLOCATED	12.37.59.0/24	7018	ATT-INTERNET4, US
33684	UNALLOCATED	12.37.144.0/24	7018	ATT-INTERNET4, US
63305	UNALLOCATED	12.49.58.0/24	7018	ATT-INTERNET4, US
33684	UNALLOCATED	12.68.34.0/24	6461	ZAYO-6461, US
31781	UNALLOCATED	12.71.107.0/24	7018	ATT-INTERNET4, US
21861	UNALLOCATED	12.106.212.0/24	7018	ATT-INTERNET4, US
12169	UNALLOCATED	12.109.164.0/24	32787	PROLEXIC-TECHNOLOGIES-DDOS-M
26295	UNALLOCATED	12.110.210.0/23	7018	ATT-INTERNET4, US
22538	UNALLOCATED	12.131.3.0/24	7018	ATT-INTERNET4, US
63248	UNALLOCATED	12.139.63.0/24	13649	ASN-VINS, US

List of Unassigned IPv4 addresses

Far too many to list (over 500!!). See <http://thyme.apnic.net/current/data-add-IANA>:

Unassigned Network	ASN Information	AS Name
23.140.216.0/24	Origin: 27176	DATAWAGON, US
23.140.216.0/24	Transit: 20278	NEXEON, US
23.141.0.0/24	Origin: 395350	RESERVED, ZZ
23.141.0.0/24	Transit: 11426	TWC-11426-CAROLINAS, US
23.176.160.0/24	Origin: 397327	RESERVED, ZZ
23.176.160.0/24	Transit: 19108	SUDDENLINK-COMMUNICATIONS, US
23.189.192.0/24	Origin: 27593	RESERVED, ZZ
23.189.192.0/24	Transit: 174	COGENT-174, US
36.255.139.0/24	Origin: 56050	NEW-SHINE-INTERNET-TH 134 Yenchit Road,
36.255.139.0/24	Transit: 58913	HCL-TH 4819 Supapong 3 Alley, Srinakarin
41.57.124.0/22	Origin: 37442	RESERVED, ZZ
41.57.124.0/22	Transit: 37204	TELONE, ZW
41.57.124.0/23	Origin: 37442	RESERVED, ZZ
41.57.124.0/23	Transit: 37204	TELONE, ZW
41.57.124.0/24	Origin: 37442	RESERVED, ZZ
41.57.124.0/24	Transit: 37204	TELONE, ZW
41.57.125.0/24	Origin: 37442	RESERVED, ZZ
41.57.125.0/24	Transit: 37204	TELONE, ZW
41.57.126.0/24	Origin: 37442	RESERVED, ZZ
41.57.126.0/24	Transit: 37204	TELONE, ZW
41.57.127.0/24	Origin: 37442	RESERVED, ZZ
41.57.127.0/24	Transit: 37204	TELONE, ZW
41.57.203.0/24	Origin: 206283	YAHSAT-FRANKFURT, AE
41.57.203.0/24	Transit: 3491	BTN-ASN, US
41.57.204.0/24	Origin: 206283	YAHSAT-FRANKFURT, AE
41.57.204.0/24	Transit: 3491	BTN-ASN, US

Number of IPv4 prefixes announced by prefix length

/1:0	/2:0	/3:0	/4:0	/5:0	/6:0	/7:0	/8:16
/9:14	/10:38	/11:101	/12:299	/13:581	/14:1193	/15:2060	/16:13486
/17:8319	/18:13869	/19:25191	/20:44498	/21:51626	/22:110461	/23:99321	/24:560903
/25:739	/26:0	/27:0	/28:0	/29:0	/30:0	/31:0	/32:0

14th October 2023↑

14th October 2022↓

/1:0	/2:0	/3:0	/4:0	/5:0	/6:0	/7:0	/8:16
/9:13	/10:39	/11:100	/12:295	/13:589	/14:1202	/15:2045	/16:13521
/17:8363	/18:13958	/19:25165	/20:44410	/21:52310	/22:109506	/23:97623	/24:542235
/25:784	/26:0	/27:0	/28:0	/29:0	/30:0	/31:0	/32:0

Number of IPv6 prefixes announced by prefix length

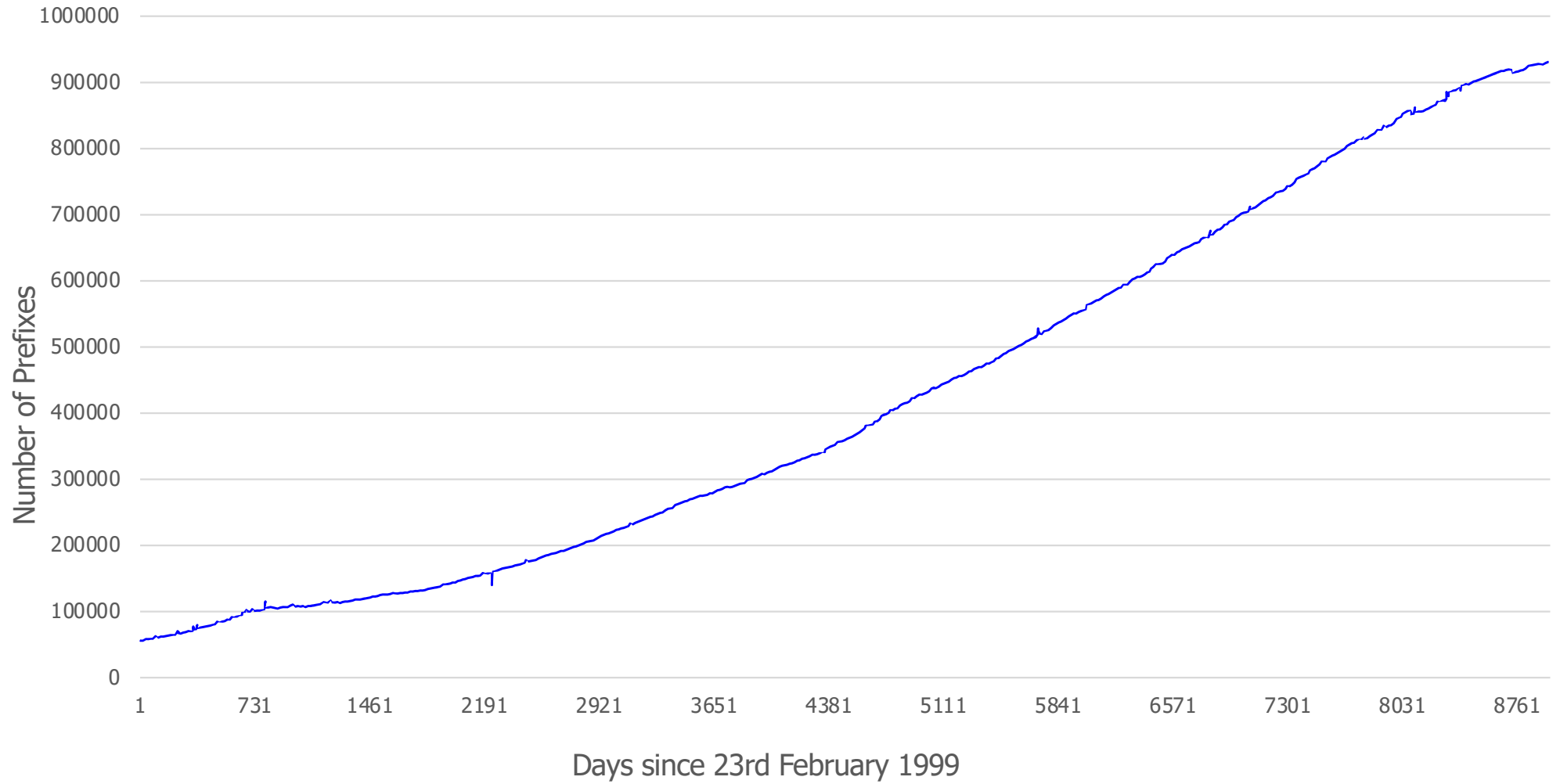
/16:1	/17:0	/18:0	/19:1	/20:14	/21:3	/22:7	/23:7
/24:32	/25:8	/26:16	/27:21	/28:209	/29:4333	/30:616	/31:319
/32:23298	/33:3277	/34:2832	/35:1016	/36:6214	/37:1003	/38:1794	/39:1337
/40:14883	/41:952	/42:3512	/43:1091	/44:16569	/45:2135	/46:3285	/47:4578
/48:88109	/49 → /128: FILTERED by ISP						

14th October 2023↑

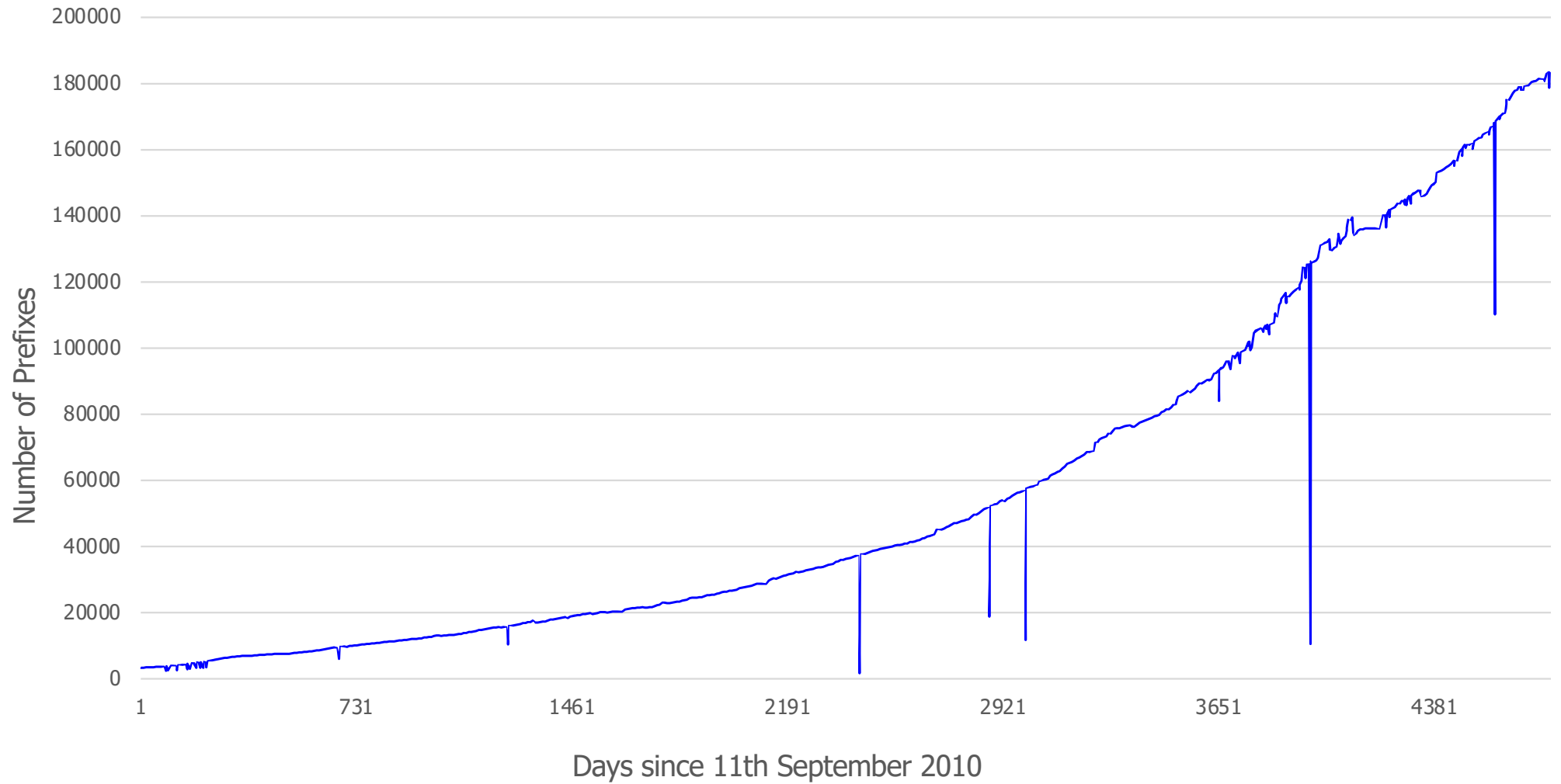
14th October 2022↓

/16:1	/17:0	/18:0	/19:1	/20:16	/21:3	/22:7	/23:7
/24:29	/25:8	/26:15	/27:20	/28:195	/29:4256	/30:625	/31:278
/32:22278	/33:2837	/34:2421	/35:1027	/36:5686	/37:811	/38:1615	/39:1171
/40:12672	/41:868	/42:2295	/43:1018	/44:13848	/45:1428	/46:3105	/47:2720
/48:74370	/49 → /128: FILTERED by ISP						

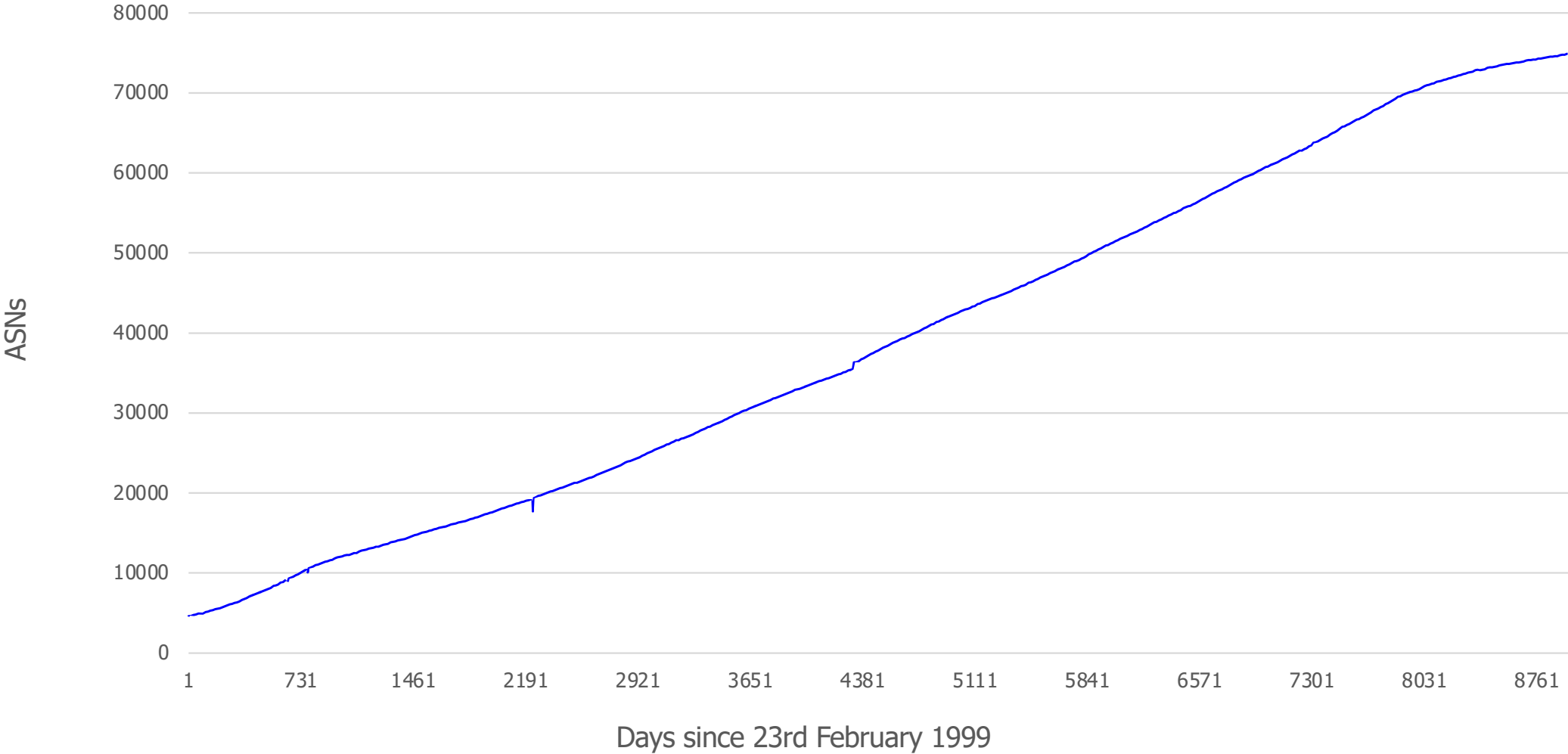
Global IPv4 Routing Table



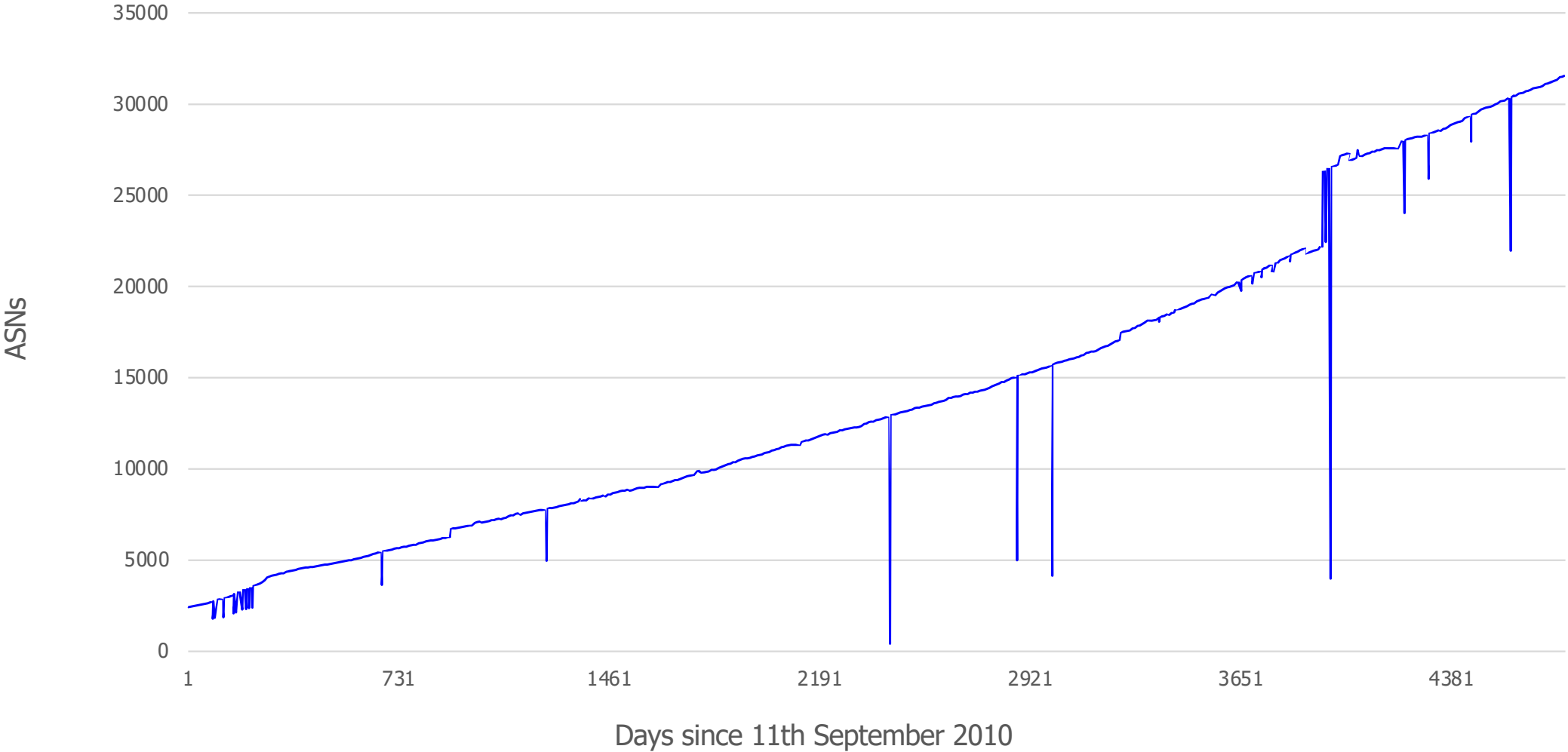
Global IPv6 Routing Table



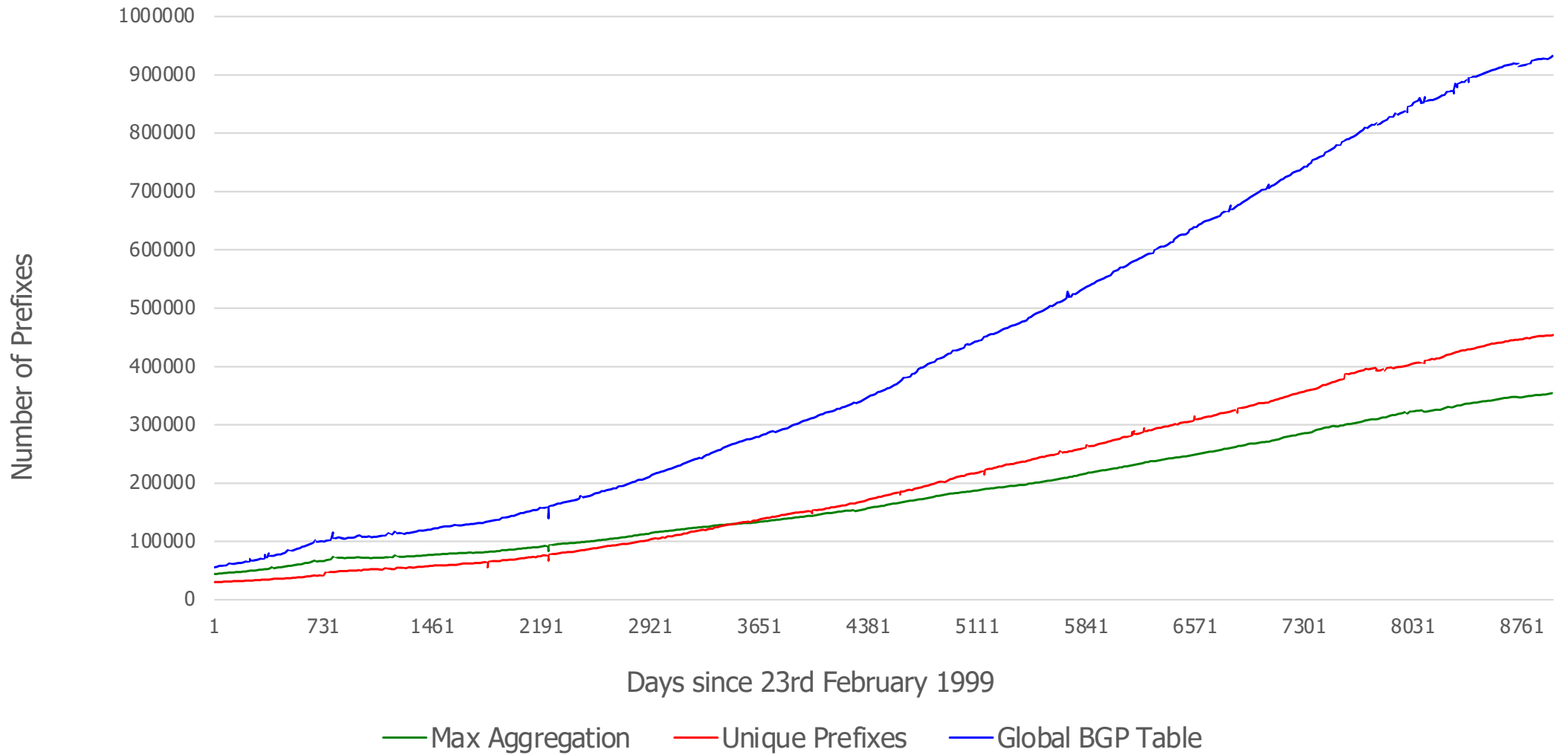
IPv4 AS Growth



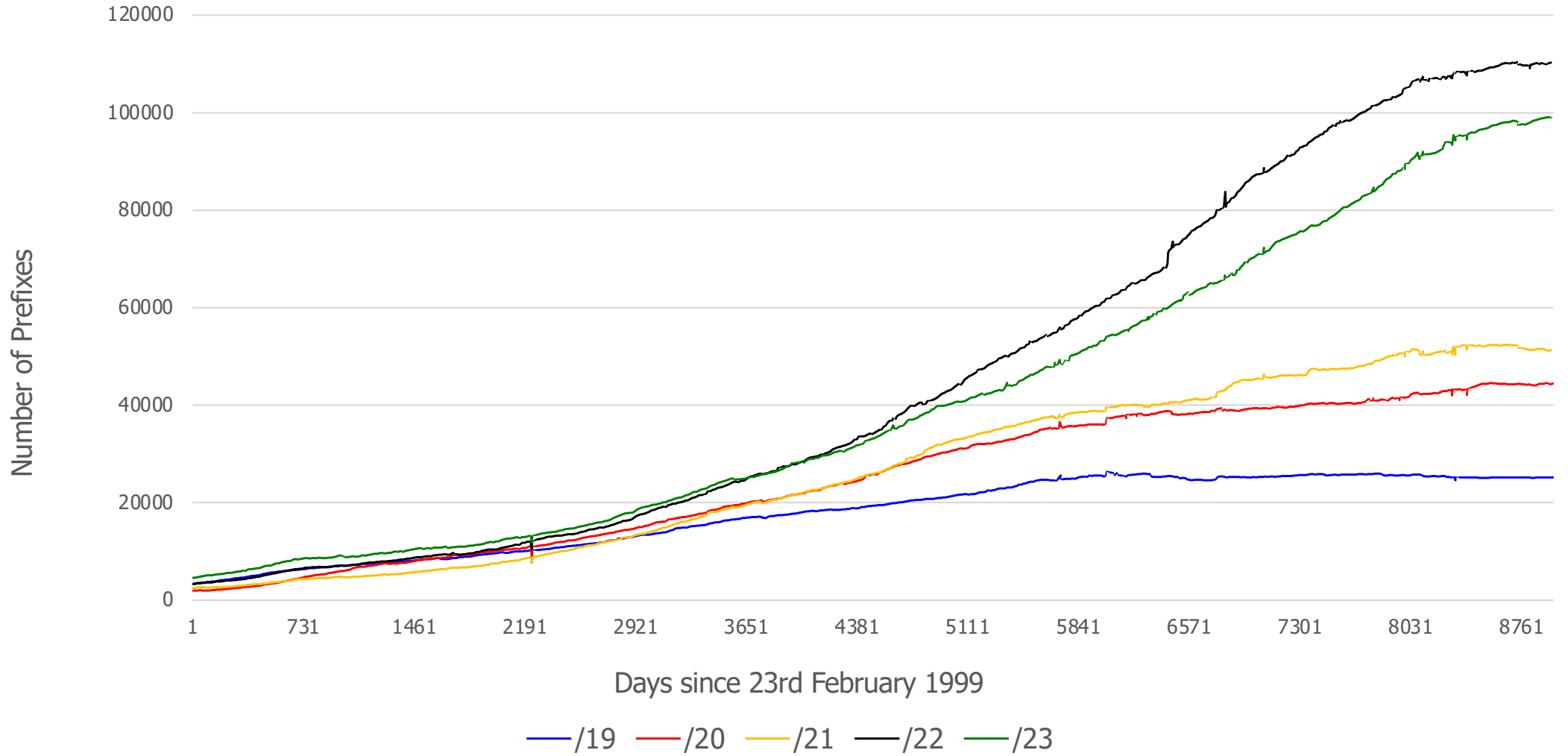
IPv6 AS Growth



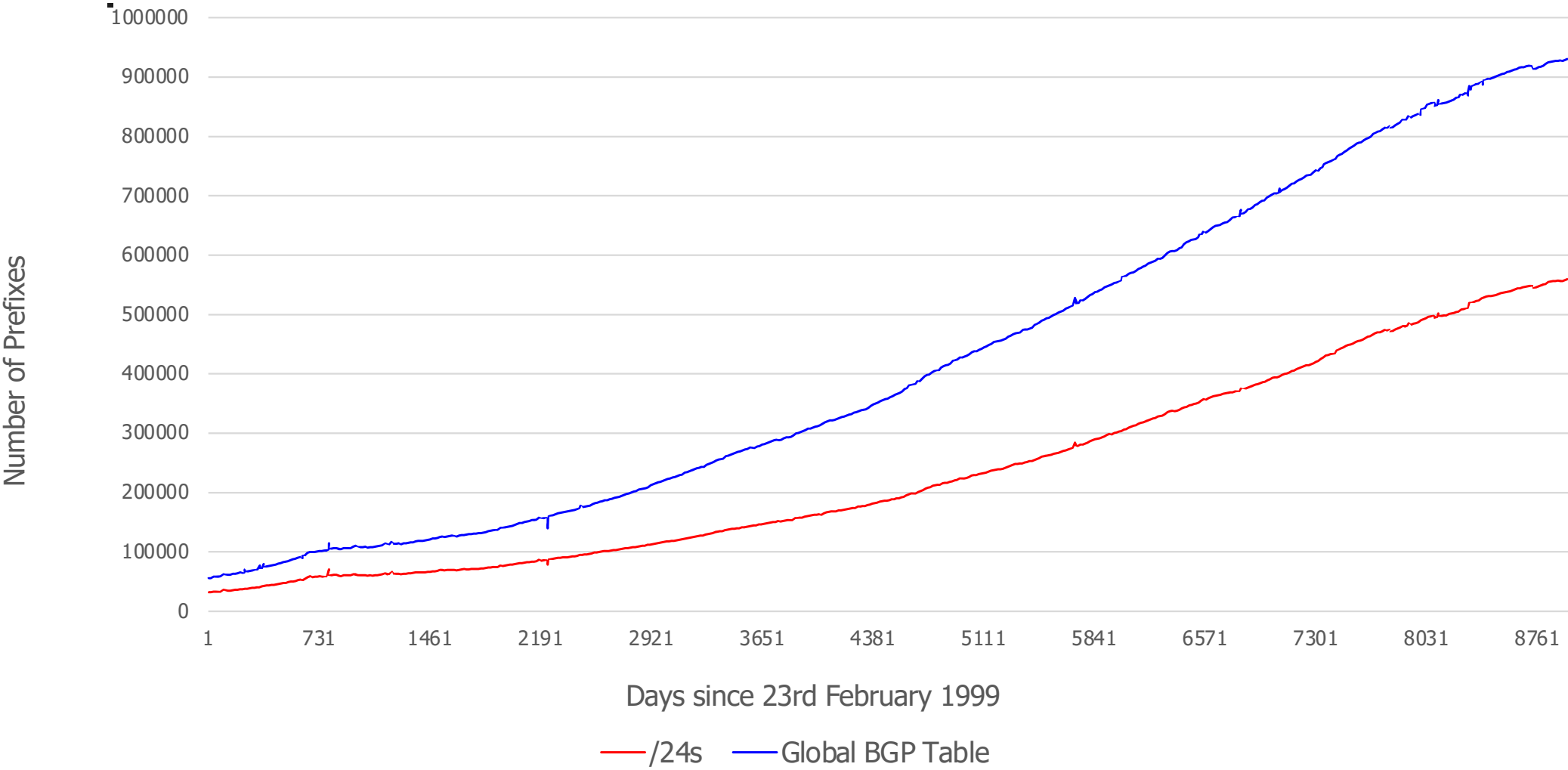
IPv4 Max Aggregation vs Unique Prefixes



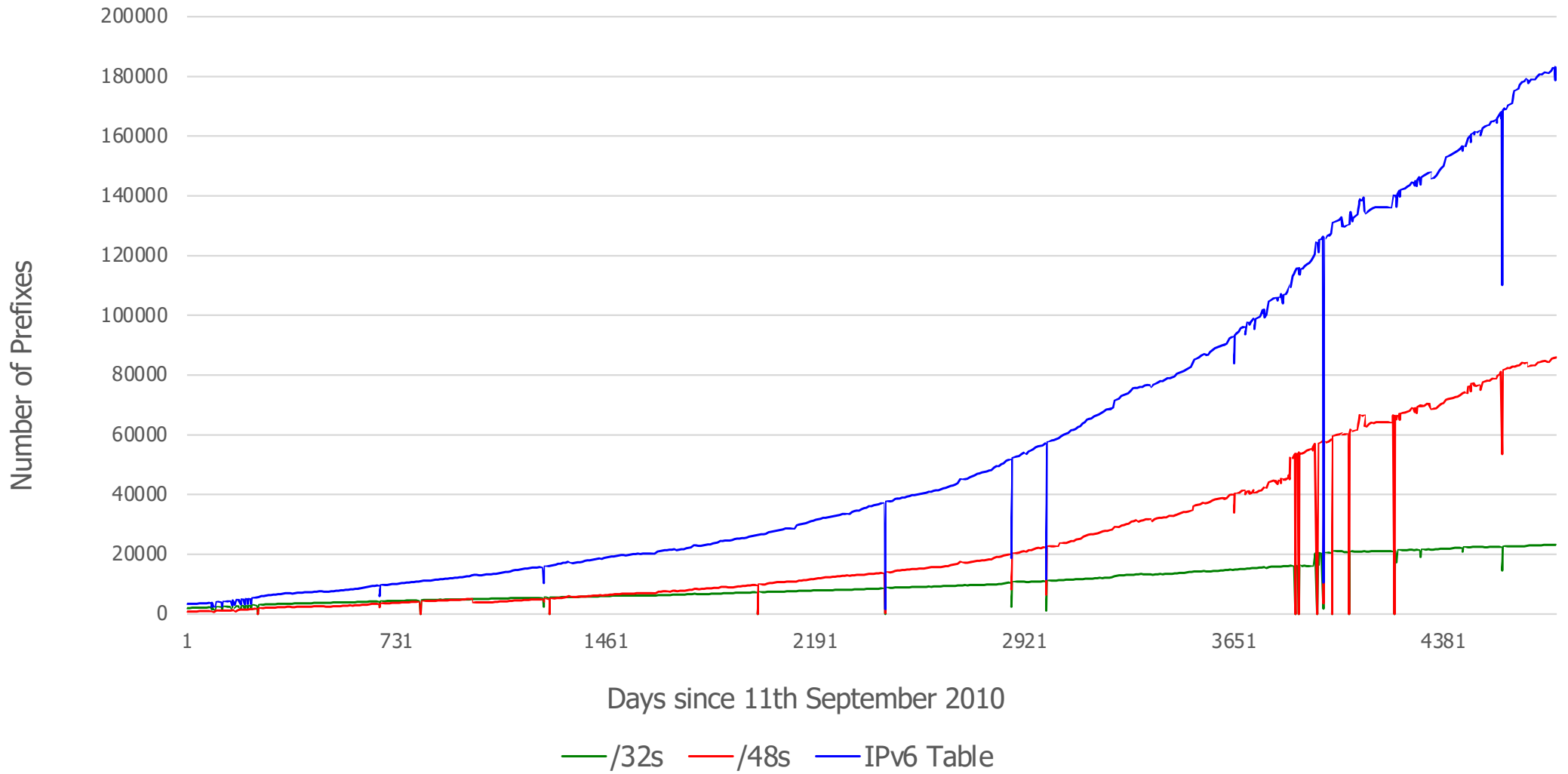
IPv4 Prefix sizes announced



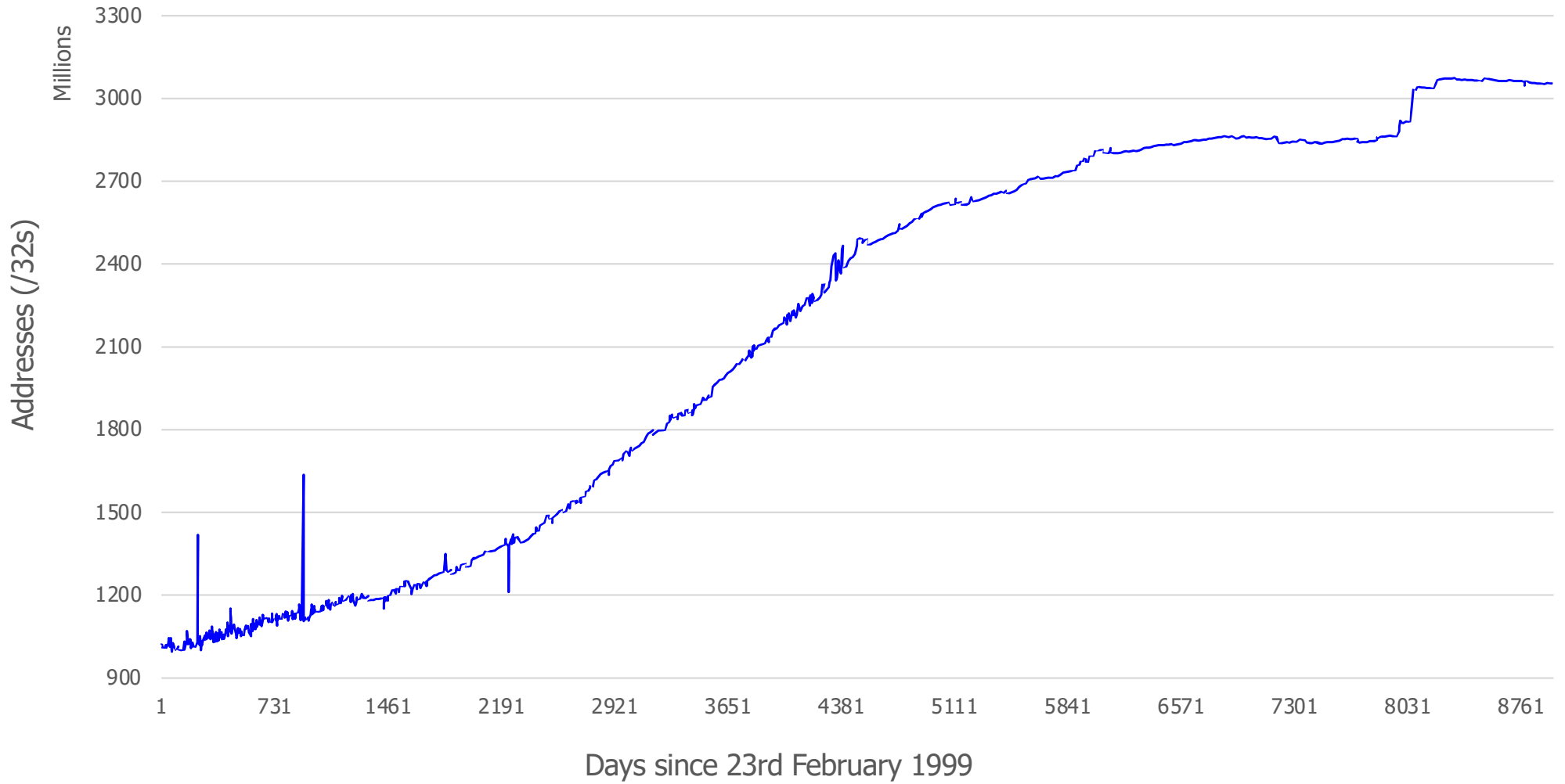
IPv4 /24s announced



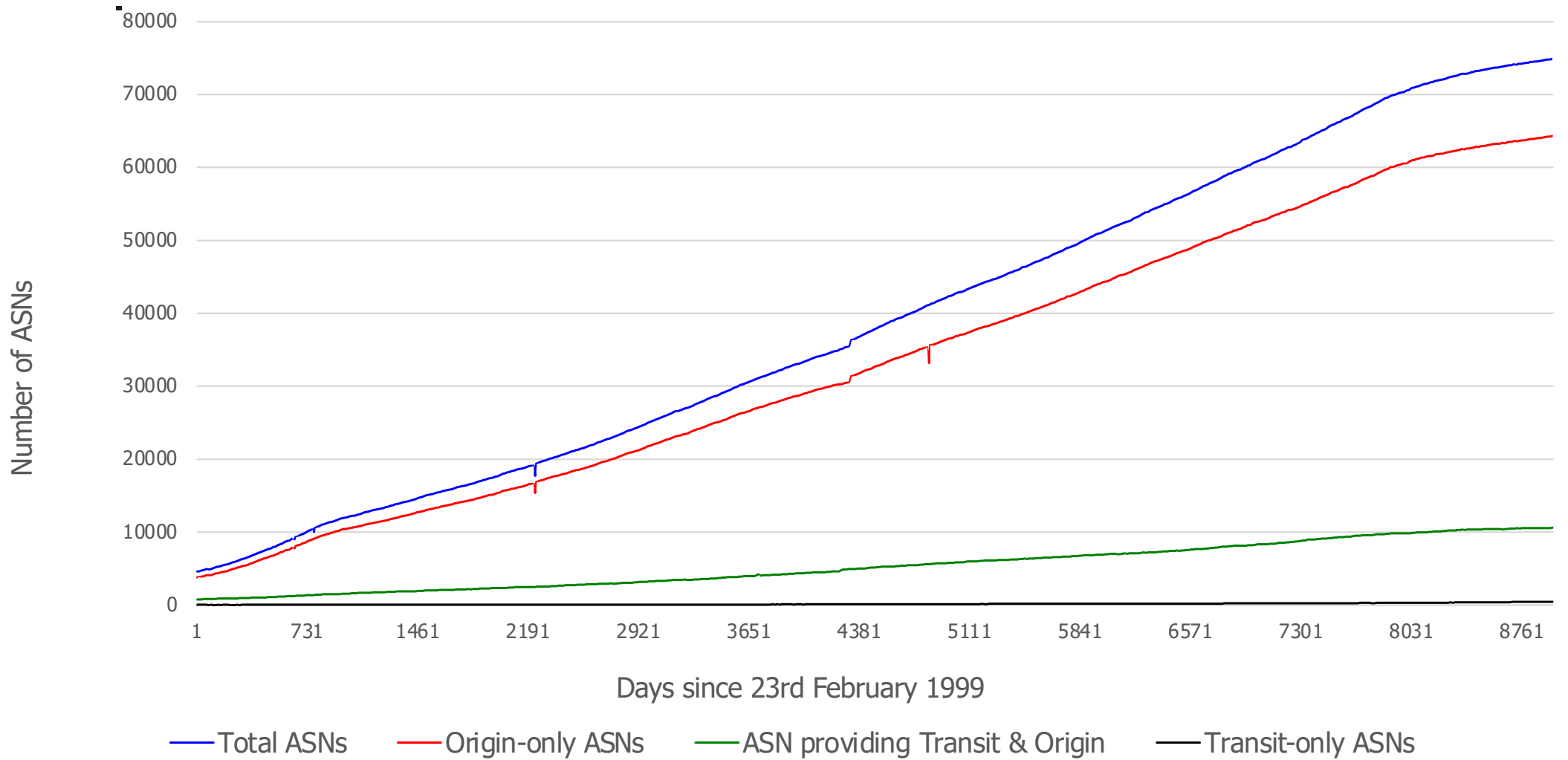
IPv6 /32s vs /48s



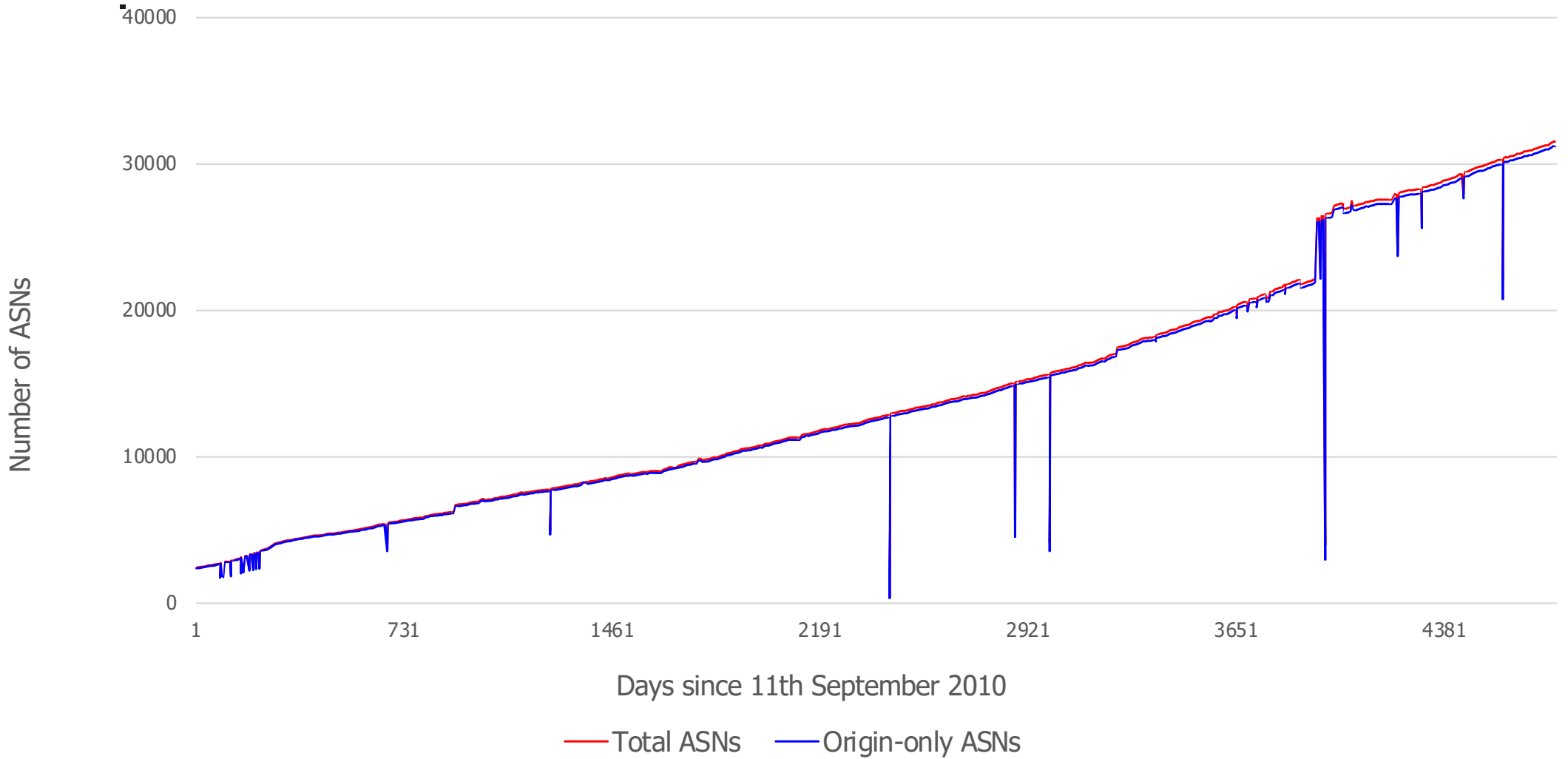
IPv4 Address Space announced



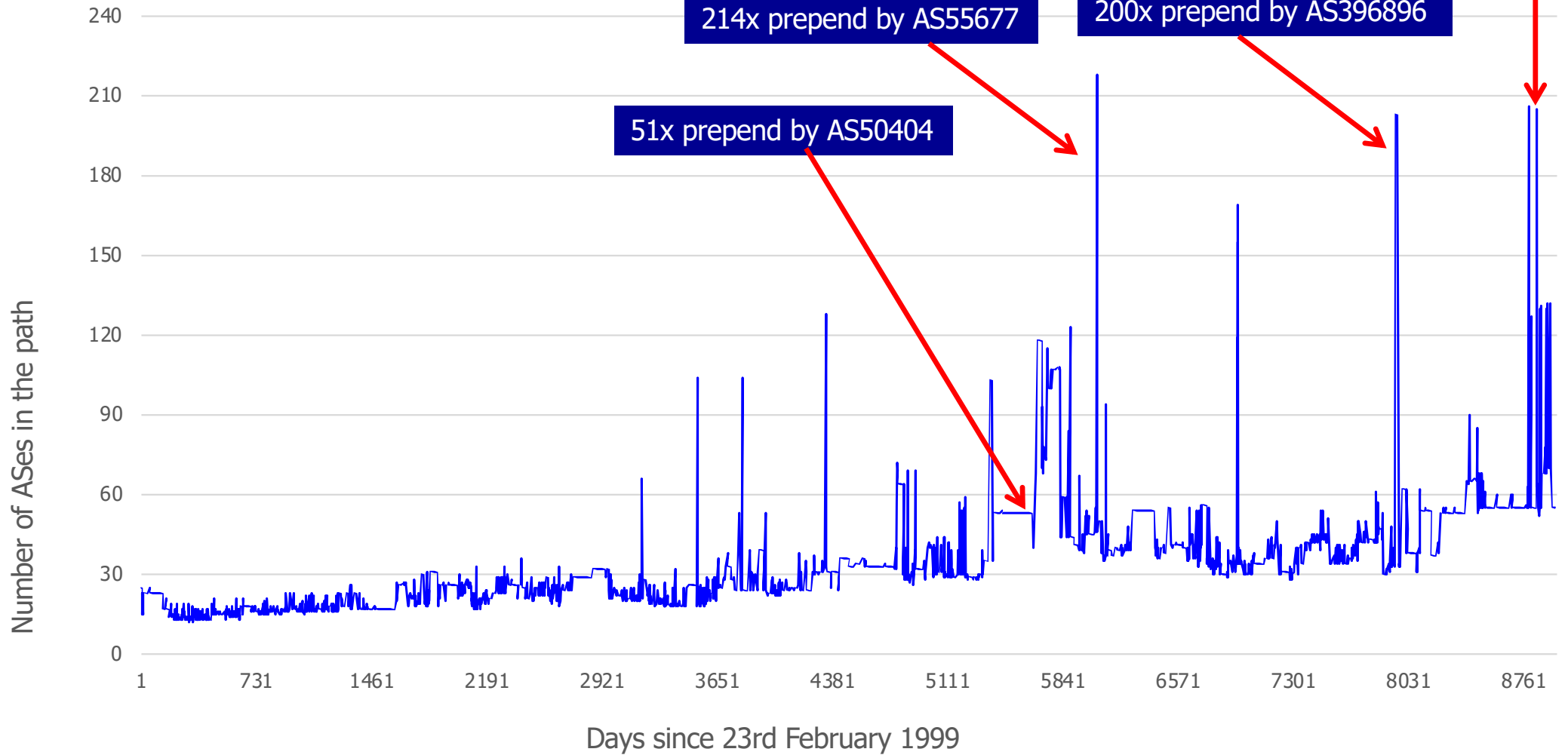
IPv4 AS Announcements



IPv6 AS Announcements



Maximum AS Path Length





Looking at Deaggregation in IPv4

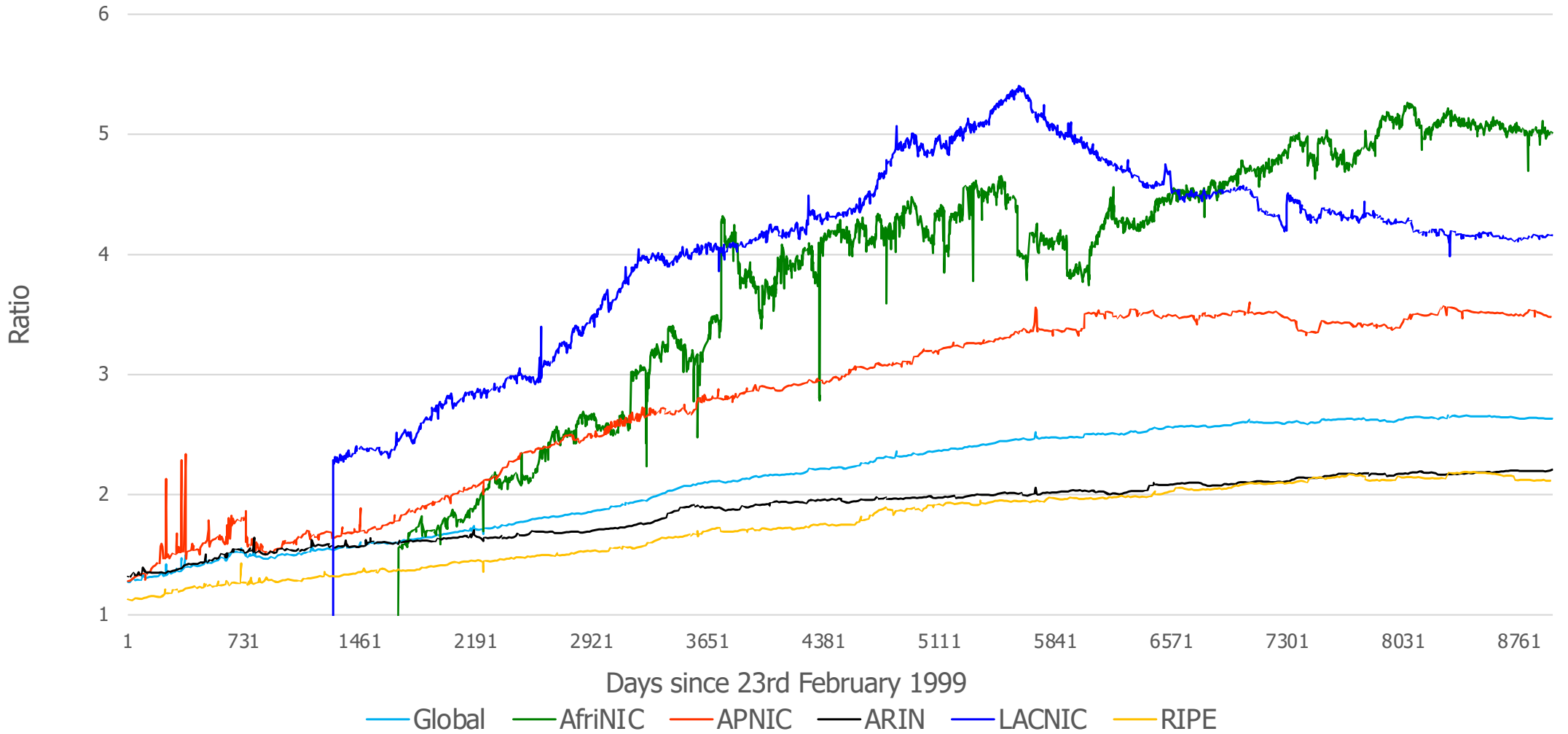
- Routing Report
 - One summary takes BGP table and aggregates prefixes by origin AS
 - Called “Max Aggregation” in report
 - Global and per RIR basis
 - <http://thyme.apnic.net/current/>
- Calculates **Deaggregation** Factor:
 - Measure of Routing Table size/Aggregated Size
 - Global value has been increasing slowly and steadily since “records began”



October 2023

- **Total Prefixes**
- Global BGP Table
 - 933k prefixes
- North America
 - 274k prefixes
- Europe & Middle East
 - 262k prefixes
- Asia & Pacific
 - 247k prefixes
- Latin America & Caribbean
 - 119k prefixes
- Africa
 - 30k prefixes
- **Deaggregation Factor**
- Global Average
 - 2.63
- North America
 - 2.21
- Europe & Middle East
 - 2.11
- Asia & Pacific
 - 3.48
- Latin America & Caribbean
 - 4.16
- Africa
 - 5.02

Deaggregation: RIR Regions vs Global



Asia Pacific Aggregation Savings Summary

ASN	No of Nets	Savings	Description
9808	9498	9455	CHINAMOBILE-CN China Mobile Communications Grou
7545	5713	5015	TPG-INTERNET-AP TPG Telecom Limited, AU
4538	4934	4859	ERX-CERNET-BKB China Education and Research Net
18403	4179	4154	FPT-AS-AP FPT Telecom Company, VN
7713	3596	3533	TELKOMNET-AS-AP PT Telekomunikasi Indonesia, ID
45899	3327	3231	VNPT-AS-VN VNPT Corp, VN
9498	3210	2961	BBIL-AP BHARTI Airtel Ltd., IN
7552	2943	2923	VIETEL-AS-AP Viettel Group, VN
24560	2547	2161	AIRTELBROADBAND-AS-AP Bharti Airtel Ltd., Telem
45090	2186	2107	TENCENT-NET-AP Shenzhen Tencent Computer System
4755	2190	1988	TATACOMM-AS TATA Communications formerly VSNL i
4766	2540	1939	KIXS-AS-KR Korea Telecom, KR
23969	1914	1898	TOT-NET TOT Public Company Limited, TH
9829	1919	1882	BSNL-NIB National Internet Backbone, IN
45609	1922	1581	BHARTI-MOBILITY-AS-AP Bharti Airtel Ltd. AS for
56047	1515	1481	CMNET-HUNAN-AP China Mobile communications corp
56041	1481	1410	CMNET-ZHEJIANG-AP China Mobile communications c
56046	1456	1362	CMNET-JIANGSU-AP China Mobile communications co
17557	1249	1215	PKTELECOM-AS-PK Pakistan Telecommunication Comp
9583	1779	1208	SIFY-AS-IN Sify Limited, IN

<http://thyme.apnic.net/current/data-CIDRnet-APNIC>

Afghanistan Aggregation Savings Summary

ASN	No of Nets	Savings	Description
38742	69	53	AWCC-AS-AP Afghan Wireless Communication Compan
55330	70	45	GCN-DCN-AS AFGHANTELECOM GOVERNMENT COMMUNICATI
17411	44	38	IO-GLOBAL-AP Io Global Services Pvt. Limited, A
131284	46	34	ETISALATAFG-AS-AP Etisalat Afghan, AF
55424	33	23	INSTATELECOM-AS-AP Instatelecom Limited, AF
132471	34	26	MTNAFGHANISTAN-AS-AP MTNAFGHANISTAN, AF
45178	28	20	ROSHAN-AF Main Street, House No. 13 Wazir Akbar
55424	28	14	INSTATELECOM-AS-AP Instatelecom Limited, AF
138322	29	13	AWCC-AS-AP Afghan Wireless Communication Compan
133066	11	7	ANS-AS-AP Ariana Network Services Co, AF

Bangladesh Aggregation Savings Summary

ASN	No of Nets	Savings	Description
23688	263	253	LINK3-TECH-AS-BD-AP Link3 Technologies Ltd., BD
23956	188	183	AMBERIT-BD-AS AmberIT Limited, BD
24342	168	163	BRAC-BDMAIL-AS-BD BRACNet Limited, BD
23923	167	162	AGNI-AS Agni Systems Limited, BD
17806	104	102	MANGOTELESERVICE-AS-BD Tire-1 IP Transit Provid
58715	123	101	EARTHTELECOMMUNICATION-AS EARTH TELECOMMUNICATI
7565	94	92	BDCOM-BD Rangs Nilu Square, 5th Floor, House 75
17469	93	84	ACCESSTEL-AS-AP Access Telecom BD Ltd., BD
9230	84	78	BOL-BD-AP Bangladesh Online Ltd., BD
24323	89	72	AAMRA-NETWORKS-AS-AP aamra networks limited, BD

India Aggregation Savings Summary

ASN	No of Nets	Savings	Description
9498	3210	2961	BBIL-AP BHARTI Airtel Ltd., IN
24560	2547	2161	AIRTELBROADBAND-AS-AP Bharti Airtel Ltd., Telem
4755	2190	1988	TATACOMM-AS TATA Communications formerly VSNL I
9829	1919	1882	BSNL-NIB National Internet Backbone, IN
45609	1922	1581	BHARTI-MOBILITY-AS-AP Bharti Airtel Ltd. AS for
9583	1779	1208	SIFY-AS-IN Sify Limited, IN
17488	1262	1135	HATHWAY-NET-AP Hathway IP Over Cable Internet,
55410	923	894	VIL-AS-AP Vodafone Idea Ltd, IN
45820	970	861	TTSL-MEISISP Tata Teleservices ISP AS, IN
38266	813	763	VIL-AS-AP Vodafone Idea Ltd, IN

Sri Lanka Aggregation Savings Summary

ASN	No of Nets	Savings	Description
9329	120	113	SLTINT-AS-AP Sri Lanka Telecom Internet, LK
18001	80	65	DIALOG-AS Dialog Axiata PLC., LK
132045	64	59	AIRTEL-AS-ISP Bharti Airtel Lanka Pvt. Limited,
45224	60	57	BELLNET-AS-AP Lanka Bell Limited, LK
5087	84	46	LANKA-COM Lanka Communication Services, LK
17904	21	19	SLTASUL-LK Sri Lankan Airlines, LK
17470	17	14	HUTCHISON-LK Hutchison Telecommunications Lanka
132447	10	8	HUTCHISON-LK 234, Galle Road, Colombo 4, LK
38229	9	7	LEARN-LK Lanka Education & Research Network, NR
45356	13	6	MOBITEL-LK Mobitel Pvt Ltd, LK

Nepal Aggregation Savings Summary

ASN	No of Nets	Savings	Description
17501	218	207	WLINK-NEPAL-AS-AP WorldLink Communications Pvt
23752	99	90	NPTELECOM-NP-AS Nepal Telecommunications Corpor
4007	80	68	SUBISU-CABLENET-AS-AP Subisu Cablenet Pvt Ltd,
4613	71	68	MOS-NP Mercantile Office Systems, NP
38565	62	58	NCELL-AS-NP Ncell Pvt. Ltd., NP
24550	61	55	WEBSURFERNP-AS-NP Websurfer Nepal Internet Serv
45650	46	28	VIANET-NP Vianet Communications Pvt. Ltd., NP
55915	33	25	CLASSIC-NP Classic Tech Pvt. Ltd., NP
55427	21	18	BROADLINK-AS-AP Broadlink Nepal, NP
141047	16	13	NDSPL-AS-AP Nepal Digital Service Pvt. Ltd., NP

Pakistan Aggregation Savings Summary

ASN	No of Nets	Savings	Description
17557	1249	1215	PKTELECOM-AS-PK Pakistan Telecommunication Comp
23674	482	456	NAYATEL-PK Nayatel Pvt Ltd, PK
9541	572	476	CYBERNET-AP Cyber Internet Services Pvt Ltd., P
45669	288	281	MOBILINK-AS-PK PMCL LDI IP TRANSIT, PK
132165	318	277	CONNECT-AS-AP Connect Communications, PK
59257	204	192	CMPAKLIMITED-AS-AP CMPak Limited, PK
38264	219	160	WATEEN-IMS-PK-AS-AP National WiMAXIMS environme
58895	207	155	EBONE1-PK Ebone Network PVT. Limited, PK
23966	163	151	LDN-AS-PK LINKdotNET Telecom Limited, PK
136525	136	126	WANCOMPVTLTD-AS-AP Wancom Pvt Ltd., PK

Maldives Aggregation Savings Summary

ASN	No of Nets	Savings	Description
7642	127	114	DHIRAAGU-MV-AP DHIVEHI RAAJJEYGE GULHUN PLC, MV
55944	68	60	OOREDOO-MV Ooredoo Maldives Plc, MV
24016	52	49	RAAJJEONLINE-AS Focus Infocom Private Limited,
136238	6	2	SATLINKPVTLLTD-AS-AP SatLink Pvt Ltd, MV

Bhutan Aggregation Savings Summary

ASN	No of Nets	Savings	Description
134715	13	9	GTA-AS-AP Government Technology Agency, BT
136039	6	4	NANO-AS-AP NANO, Bhutan, BT
141680	2	1	SUPERNET1-AS-AP SuperNet Infocomm, BT



IPv4 Observations

- Routing table continues to grow
 - Linear growth for last 8 years
 - Even though total address space announced has levelled off over the last 3 years
- /24 announcements continue to grow
 - Clearly many operators are deaggregating down to the smallest prefix size considered routable
 - Do operators still filter prefix sizes smaller than /24?
 - (A few /25s through /32s are visible)
- Overall global deaggregation ratio growth has slowed
 - Significant improvements in Latin America



IPv6 Observations

- Routing table growth has continued in 2023
 - How to interpret this?
- /48 announcements continue to grow rapidly
 - Operators seem to believe that IPv6 /48 needs to be treated like IPv4 /24 🙄😞
- Noticeable increases:
 - According to RIR allocation boundaries
 - Along nibble boundaries



Internet Routing Table Analysis Update

Questions?