



# Internet Routing Table Analysis Update

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SANOG 39

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# Motivation

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- 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 23<sup>rd</sup> 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 8<sup>th</sup> May 2023

BGP routing table entries examined:	921157
Prefixes after maximum aggregation (per Origin AS):	349170
Deaggregation factor:	2.64
Unique aggregates announced (without unneeded subnets):	448372
Total ASes present in the Internet Routing Table:	74402
Prefixes per ASN:	12.38
Origin-only ASes present in the Internet Routing Table:	63833
Origin ASes announcing only one prefix:	26242
Transit ASes present in the Internet Routing Table:	10569
Transit-only ASes present in the Internet Routing Table:	436
Average AS path length visible in the Internet Routing Table:	4.3
Max AS path length visible:	55
Max AS path prepend of ASN (265020)	50
Prefixes from unregistered ASNs in the Routing Table:	1081
Number of instances of unregistered ASNs:	1081
Special use prefixes present in the Routing Table:	1
Prefixes being announced from unallocated address space:	620
Number of addresses announced to Internet:	3059798912
Equivalent to 182 /8s, 96 /16s and 211 /24s	
Total number of prefixes smaller than registry allocations:	307538

## APNIC Region

Prefixes being announced by APNIC Region ASes:	244227
Total APNIC prefixes after maximum aggregation:	69438
APNIC Deaggregation factor:	3.52
Prefixes being announced from the APNIC address blocks:	238361
Unique aggregates announced from the APNIC address blocks:	97957
APNIC Region origin ASes present in the Internet Routing Table:	13427
APNIC Prefixes per ASN:	17.75
APNIC Region origin ASes announcing only one prefix:	3960
APNIC Region transit ASes present in the Internet Routing Table:	1801
Average APNIC Region AS path length visible:	4.5
Max APNIC Region AS path length visible:	26
Number of APNIC addresses announced to Internet:	773570304
Equivalent to 46 /8s, 27 /16s and 191 /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, 131072-151865
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	11263	3328	593	Uninet S.A. de C.V., MX
9808	9486	8706	40	CHINAMOBILE-CN China Mobile Communicati
16509	8282	10783	2930	AMAZON-02, US
12479	7282	1707	141	UNI2-AS, ES
7545	5727	787	694	TPG-INTERNET-AP TPG Telecom Limited, AU
4538	4863	4192	75	ERX-CERNET-BKB China Education and Rese
39891	4833	286	59	ALJAWWALSTC-AS, SA
11492	4534	300	609	CABLEONE, US
20940	4080	3399	164	AKAMAI-ASN1, NL
45899	4054	1877	47	VNPT-AS-VN VNPT Corp, VN
7155	3975	281	51	VIASAT-SP-BACKBONE, US
8551	3884	370	37	BEZEQ-INTERNATIONAL-AS Bezeqint Interne
22773	3587	3057	283	ASN-CXA-ALL-CCI-22773-RDC, US
7713	3560	1043	65	TELKOMNET-AS-AP PT Telekomunikasi Indon
6327	3525	1320	64	SHAW, CA
10620	3518	508	855	Telmex Colombia S.A., CO
7552	3227	1331	21	VIETEL-AS-AP Viettel Group, VN
16625	3117	1578	2358	AKAMAI-AS, US
749	3101	54980	2353	DNIC-AS-00749, US
12389	2952	2292	909	ROSTELECOM-AS, RU

AfriNIC APNIC ARIN LACNIC RIPE NCC



# What about IPv6 ?

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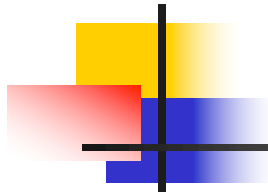
## IPv6 Routing Report 8<sup>th</sup> May 2023 (London)

BGP routing table entries examined:	171005
Number of IPv6 prefixes with a valid ROA:	84842
Number of IPv6 prefixes with an invalid ROA:	606
Number of IPv6 prefixes with no ROA:	85557
Total ASNs present in the IPv6 Routing Table:	30541
Average AS path length:	4.9
Longest AS path:	58
Total Origin ASNs present in the IPv6 Routing Table:	30250

## Global IPv6 per AS prefix count summary (London)

ASN	No of Nets	Description
11172	5347	Alestra, S. de R.L. de C.V., MX
9808	4355	CHINAMOBILE-CN China Mobile Communications Group Co., Ltd.,
16509	3430	AMAZON-02, US
45609	2438	BHARTI-MOBILITY-AS-AP Bharti Airtel Ltd. AS for GPRS Service
17622	2315	CNCGROUP-GZ China Unicom Guangzhou network, CN
7552	2196	VIETEL-AS-AP Viettel Group, VN
24547	1827	CMNET-V4HEBEI-AS-AP Hebei Mobile Communication Company Limit
28573	1827	Claro NXT Telecomunicacoes Ltda, BR
45271	1756	ICLNET-AS-AP Idea Cellular Limited, IN
12479	1622	UNI2-AS, ES
17623	1447	CNCGROUP-SZ China Unicom Shenzen network, CN
36183	1369	AKAMAI-AS, US
32098	1336	TRANSTELCO-INC, US
39891	1326	ALJAWWALSTC-AS, SA
38266	1280	VIL-AS-AP Vodafone Idea Ltd, IN
13335	1276	CLOUDFLARENET, US
17072	1253	TOTAL PLAY TELECOMUNICACIONES SA DE CV, MX
22773	1238	ASN-CXA-ALL-CCI-22773-RDC, US
56046	1132	CMNET-JIANGSU-AP China Mobile communications corporation, CN
62240	1122	CLOUIDER Clouvider - Global ASN, GB

AfriNIC APNIC ARIN LACNIC RIPE NCC



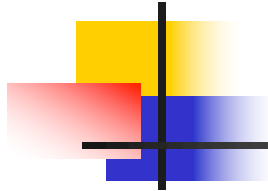
# IPv6 deaggregation - Alestra

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 11172 i
V*> 2001:1248:4::/48	6453 1299 11172 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 11172 i
V*> 2001:1248:88fd::/48	6453 1299 11172 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 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" ?





# Non-routable ASNs for IPv4

Network	Path
N*> 41.85.127.0/24	30844 22355 420000000
N*> 41.174.100.0/22	30844 30969 64631
N*> 41.174.112.0/21	30844 30969 64631
N*> 41.174.160.0/20	30844 30969 64631
N*> 41.175.128.0/20	30844 30969 64631
N*> 102.212.180.0/24	30844 36962 64945
N*> 102.221.75.0/24	6453 174 327708 36873 36873 761467
N*> 103.123.12.0/24	6453 3491 4826 17828 17828 17828 17828 1440665
V*> 150.107.29.0/24	6453 1273 4651 4651 4651 135063 135063 103563 135063 103563 136523
N*> 196.216.75.0/24	30844 37485 65200
I*> 202.185.181.0/24	9930 65295
I*> 202.185.188.0/24	9930 65295
N*> 206.42.66.0/24	30844 37447 65510
I*> 211.25.240.0/22	9930 65295
I*> 211.25.244.0/22	9930 65295

## IANA Reserved ASN

### Private ASN

**AS9930 – Time Telecom Berhad**

**AS17828 – PNG Dataco Ltd**

**AS22355 – Frogfoot Networks**

**AS30969 – Zimbabwe Online**

**AS36873 – Celtel Nigeria**

**AS36962 – MTN Zambia**

**AS37447 – Wang New Zealand**

**AS37485 – Liquid Zimbabwe**

**AS135063 – POP NIX Company Limited**



# Non-routable ASNs for IPv6

```
Network          Path
N*> 2001:948::/29 2603 {224,1653,39590,64530,64540,64541,64565,65002,65003,65004,65005,65006,65007,65008,65009,65010,65011,65430}
N*> 2001:448a:5010::/48 6453 174 7713 64505
N*> 2001:448a:5050::/48 6453 174 7713 64501
N*> 2001:448a:5051::/48 6453 174 7713 64501
N*> 2001:448a:5052::/48 6453 174 7713 64501
N*> 2001:448a:5053::/48 6453 174 7713 64501
N*> 2001:448a:5054::/48 6453 174 7713 64501
N*> 2001:448a:5055::/48 6453 174 7713 64501
N*> 2001:448a:5056::/48 6453 174 7713 64501
N*> 2001:448a:5057::/48 6453 174 7713 64501
N*> 2001:448a:5058::/48 6453 174 7713 64501
N*> 2001:448a:5059::/48 6453 174 7713 64501
N*> 2001:448a:505a::/48 6453 174 7713 64501
N*> 2001:448a:505b::/48 6453 174 7713 64501
<snip>
N*> 2001:448a:50bc::/48 6453 174 7713 64500
N*> 2001:448a:50bd::/48 6453 174 7713 64500
N*> 2001:448a:50be::/48 6453 174 7713 64500
N*> 2001:448a:50bf::/48 6453 174 7713 64500
N*> 2001:448a:c050::/48 6453 174 7713 64501
N*> 2001:448a:c0b0::/48 6453 174 7713 64500
N*> 2407:2840::/48 58453 9808 56040 65270 58828
N*> 2a0c:a641::/32 6453 3257 8781 42298 65540
```

## Documentation ASN

## Private ASN

**AS2603 - Nordunet**

**AS7713 – Telekom Indonesia**

**AS56040 – China Mobile**

**AS58828 – Guangdong Rural Credit Union**

**AS42298 – Ooredoo**



# Deprecated AS Set

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- 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 263 entries
  - IPv6 has 35 entries

## IPv4 Prefixes using Deprecated AS\_SET

Net Originated	AS Path
5.28.168.0/21	3356 6453 12849 {8894}
8.41.202.0/24	13789 13789 13789 13789 13789 13789 13789 13789 13789 30372 {40179}
15.36.64.0/18	7660 4635 2687 25888 {21326}
20.133.40.0/21	3356 22562 {17916}
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	701 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}
37.52.0.0/14	1299 6849 {6877}
37.142.0.0/17	6762 8657 12849 {21450,205209}
37.142.128.0/17	1299 8657 12849 {21450}
37.221.128.0/19	3257 3255 {62384}
41.196.32.0/20	6762 8452 24863 {37069}
41.196.34.0/23	3257 8452 24863 24863 24863 24863 24863 24863 {37069}
41.215.160.0/20	6762 37613 37030 {37140}
41.215.162.0/24	6762 37613 37030 {37140}
...	
216.16.208.0/20	3257 22646 {400511}
216.55.208.0/21	6327 15830 {394255}
216.110.102.0	3491 23520 14813 {11139}
216.126.96.0/20	577 22573 {6058}
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}
216.241.2.0	6461 52320 52468 52468 52468 52468 18747 {27651,65552}
216.241.10.0	6461 52320 52468 52468 52468 52468 18747 {52411}
216.245.192.0/19	174 46475 {397666}
217.24.112.0/20	12389 {28860}
217.25.32.0/20	1299 3301 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 30943 30943 30943 {40966}

## IPv6 Prefixes using Deprecated AS\_SET

Net Originated	AS Path
2001:410::/32	7660 22388 11537 6509 {271,7860,8111,10972,53904}
2001:510::/32	7660 22388 11537 6509 376 {36786}
2001:678:16::/48	7660 2516 12389 45029 42385 {20764,42385,43832}
2001:678:6d0::/48	7660 2516 1273 3216 212748 {212748}
2001:6a0::/32	7660 2516 6939 8664 {8890}
2001:6d0:8000::/48	8359 8985 {42385}
2001:df0:2f40::/48	7660 2516 6939 149290 {1234,4321}
2001:4220::/32	7660 2516 1273 24835 {36935}
2001:4220::/33	7660 2516 1273 24835 {36935}
2001:43f8:1700::/47	7660 2516 37271 32437 328365 {31128}
2001:4818:5000::/36	577 15830 {30715}
2402:4640::/33	7660 2516 4788 38044 {23736}
2402:4640:8000::/33	7660 2516 4788 38044 {23736}
2402:7500::/32	4713 2914 9924 9924 9924 9924 9924 9924 9924 9924 9924 {24158}
2403:8400::/48	9498 17917 {36040}
2404:c000::/32	7660 2516 7473 45147 {16625,17727,55818}
2404:c000::/33	7660 2516 7473 45147 {16625,55818}
2600:140f:d400::/48	4637 55410 {16625}
2604:7ac0:e00::/40	3356 12213 {29802}
2606:5c80::/32	7660 2516 577 15830 {394255}
2606:b400:8814::/48	3356 7160 {7160}
2607:f280::/31	7660 2516 174 14615 {46218,398053}
2607:f280::/32	7660 2516 3356 14615 {398053}
2607:f390::/32	7660 22388 11537 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}
2800:800:930::/48	2914 3491 14080 {26611}
2800:800:950::/48	2914 3491 14080 14080 14080 14080 14080 14080 14080 14080 14080 {26611}
2800:800:960::/48	2914 3491 14080 {26611}
2800:800:970::/48	2914 3491 14080 14080 14080 14080 14080 14080 14080 14080 14080 {26611}
2a00:6480::/32	7660 2516 3320 35548 35548 35548 35548 {29018}
2a02:2578:2001::/48	3356 39386 51375 {211612}
2a02:6680:1::/48	174 8551 16116 {211612}
2a09:bd00::/48	12389 45029 42385 {20764,42385,43832}
2a0e:b2c4::/30	2914 3356 9002 212748 {212748}



## Unassigned resources

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- Use of unassigned address space is rampant
  - Currently 620 unassigned prefixes in IPv4 routing table
- Use of unassigned ASNs is also a big problem
  - Currently 540 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, 3507, 4879, 6081, 6485, 6565, 7064, 10425, 10475, 10981, 11011, 11044, 11091, 11223, 11316, 11490,  
11610, 11636, 11784, 11825, 11945, 11969, 12169, 12176, 12240, 13224, 13317, 13339, 13342, 13492, 13717, 13722,  
13980, 14015, 14076, 14167, 14350, 14428, 14461, 14545, 14605, 14651, 14889, 15037, 15178, 15200, 15220, 15329,  
15804, 16615, 16666, 16679, 16769, 16804, 16860, 17341, 18591, 18691, 18781, 18798, 18805, 18821, 18838, 18976,  
19081, 19140, 19142, 19176, 19359, 19507, 19533, 19708, 19987, 20118, 20190, 20200, 20227, 20421, 20443, 20447,  
21584, 21695, 21861, 21942, 21986, 22160, 22271, 22272, 22484, 22538, 22539, 22694, 22698, 22733, 22736, 22743,  
22774, 22778, 22830, 23021, 23176, 23190, 23194, 23262, 23288, 23357, 23411, 23448, 23507, 23985, 25568, 25600,  
25641, 25647, 25800, 25831, 25978, 26016, 26018, 26051, 26140, 26171, 26286, 26295, 26341, 26345, 26520, 26643,  
26682, 26701, 26712, 26750, 26758, 26759, 26799, 26861, 26922, 26961, 26986, 27174, 27180, 27247, 27284, 27289,  
27291, 27335, 27426, 27470, 29763, 29782, 29829, 29855, 30004, 30037, 30104, 30155, 30426, 30442, 30544, 30550,  
30581, 30699, 31781, 31813, 32021, 32103, 32121, 32187, 32282, 32346, 32358, 32497, 32534, 32596, 32772, 32801,  
32842, 32916, 33008, 33017, 33027, 33051, 33123, 33137, 33177, 33223, 33232, 33245, 33394, 33417, 33484, 33492,  
33625, 33684, 35941, 36002, 36077, 36264, 36267, 36283, 36357, 36465, 36679, 36774, 36893, 36900, 36928, 36945,  
36979, 37010, 37034, 37103, 37155, 37162, 37169, 37320, 37338, 37442, 37475, 37476, 37544, 37555, 37591, 37672,  
37703, 38055, 39991, 40004, 40186, 40255, 40279, 40503, 40600, 40687, 40745, 40751, 40909, 40920, 46086, 46123,  
46226, 46228, 46233, 46355, 46472, 46559, 46673, 46766, 46772, 46815, 46876, 46916, 47044, 47069, 47086, 47089,  
52578, 53025, 53059, 53298, 53367, 53419, 53552, 53657, 53715, 53771, 53775, 53786, 53854, 53886, 53929, 53947,  
54209, 54215, 54218, 54231, 54278, 54338, 54424, 54753, 54776, 54787, 55126, 55227, 55289, 56096, 62641, 62770,  
62801, 62820, 62828, 63092, 63125, 63190, 63198, 63248, 63305, 63387, 63401, 63433, 64011, 64203, 64339, **65540**,  
**65544**, **65646**, **65777**, **65778**, 65989, 133457, 133866, 134458, 137245, 137276, 138032, 138465, 138611, 140667,  
141432, 141687, 142626, 147295, 227171, 230105, 262495, 262509, 262692, 262992, 264493, 265039, 267948, 268652,  
269104, 271349, 271442, 271675, 271724, 327869, 327924, 327933, 328007, 328078, 328123, 328149, 328226, 328248,  
328369, 328771, 393218, 393266, 393305, 393314, 393320, 393377, 393446, 393491, 393587, 393958, 393980, 394076,  
394156, 394183, 394293, 394402, 394519, 394607, 394721, 394787, 394788, 394879, 394936, 394939, 395270, 395282,  
395350, 395376, 395377, 395438, 395514, 395522, 395556, 395557, 396015, 396330, 396451, 396894, 396993, 397607,  
397658, 398118, 398829

## 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
3507	UNALLOCATED	5.105.69.0/24	213035	AS-SERVERION Serverion B.V.,
3507	UNALLOCATED	5.105.206.0/24	213035	AS-SERVERION Serverion B.V.,
33492	UNALLOCATED	8.6.184.0/23	33650	COMCAST-33650, US
33123	UNALLOCATED	8.10.69.0/24	11168	SCC, US
12169	UNALLOCATED	8.15.207.0/24	32787	PROLEXIC-TECHNOLOGIES-DDOS-M
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
18798	UNALLOCATED	8.40.106.0/24	6461	ZAYO-6461, 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	174	COGENT-174, US
26345	UNALLOCATED	12.21.93.0/24	40264	TWC-40264-WI-MN-UPPERMI-C3,
26341	UNALLOCATED	12.33.109.0/24	7018	ATT-INTERNET4, US
21861	UNALLOCATED	12.37.59.0/24	7018	ATT-INTERNET4, US
33684	UNALLOCATED	12.37.144.0/24	7018	ATT-INTERNET4, US
13317	UNALLOCATED	12.44.10.0/24	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



## 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
37442	UNALLOCATED	41.57.124.0/22	37204	TELONE, ZW
37442	UNALLOCATED	41.57.124.0/23	37204	TELONE, ZW
37442	UNALLOCATED	41.57.124.0/24	37204	TELONE, ZW
37442	UNALLOCATED	41.57.125.0/24	37204	TELONE, ZW
37442	UNALLOCATED	41.57.126.0/24	37204	TELONE, ZW
37442	UNALLOCATED	41.57.127.0/24	37204	TELONE, ZW
37103	UNALLOCATED	41.57.214.0/24	37613	Dolphin-Telecom-AS, GH
37103	UNALLOCATED	41.57.215.0/24	37613	Dolphin-Telecom-AS, GH
37155	UNALLOCATED	41.72.0.0/23	17400	EBONET, AO
37155	UNALLOCATED	41.72.2.0/23	17400	EBONET, AO
37155	UNALLOCATED	41.72.4.0/22	17400	EBONET, AO
37155	UNALLOCATED	41.72.8.0/21	17400	EBONET, AO
37155	UNALLOCATED	41.72.16.0/21	17400	EBONET, AO
37155	UNALLOCATED	41.72.24.0/21	17400	EBONET, AO
37155	UNALLOCATED	41.72.32.0/20	17400	EBONET, AO
37155	UNALLOCATED	41.72.56.0/23	17400	EBONET, AO
37155	UNALLOCATED	41.72.60.0/23	17400	EBONET, AO
37155	UNALLOCATED	41.72.62.0/24	17400	EBONET, AO
37169	UNALLOCATED	41.72.240.0/24	16058	Gabon-Telecom, GA
37544	UNALLOCATED	41.74.32.0/24	15964	CAMNET-AS, CM
37544	UNALLOCATED	41.74.39.0/24	15964	CAMNET-AS, CM
37544	UNALLOCATED	41.74.40.0/24	15964	CAMNET-AS, CM
37544	UNALLOCATED	41.74.44.0/24	15964	CAMNET-AS, CM
37162	UNALLOCATED	41.76.25.0/24	37012	ComSysGH-AS, GH
37320	UNALLOCATED	41.77.64.0/21	29614	GHANATEL-AS, GH
37475	UNALLOCATED	41.77.208.0/22	15964	CAMNET-AS, CM

## List of Unassigned IPv4 addresses

Far too many to list (over 600!!). See <http://thyme.apnic.net/current/data-add-IANA>:

Unassigned Network	ASN Information	AS Name
23.139.232.0/24	Origin: 211619	MAXKO, HR
23.139.232.0/24	Transit: 42864	GIGANET-HU GigaNet Internet Service Prov
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	UNASSIGNED
23.141.0.0/24	Transit: 11426	TWC-11426-CAROLINAS, US
27.100.7.0/24	Origin: 56096	UNASSIGNED
27.100.7.0/24	Transit: 45455	TH-2S1N-AP Two S One N Co Ltd, Internet
41.57.124.0/22	Origin: 37442	UNASSIGNED
41.57.124.0/22	Transit: 37204	TELONE, ZW
41.57.124.0/23	Origin: 37442	UNASSIGNED
41.57.124.0/23	Transit: 37204	TELONE, ZW
41.57.124.0/24	Origin: 37442	UNASSIGNED
41.57.124.0/24	Transit: 37204	TELONE, ZW
41.57.125.0/24	Origin: 37442	UNASSIGNED
41.57.125.0/24	Transit: 37204	TELONE, ZW
41.57.126.0/24	Origin: 37442	UNASSIGNED
41.57.126.0/24	Transit: 37204	TELONE, ZW
41.57.127.0/24	Origin: 37442	UNASSIGNED
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
41.57.205.0/24	Origin: 206283	YAHSAT-FRANKFURT, AE
41.57.205.0/24	Transit: 3491	BTN-ASN, US

## List of Unassigned IPv4 addresses

Far too many to list (over 600!!). See <http://thyme.apnic.net/current/data-add-IANA>:

Unassigned Network	ASN Information	AS Name
41.76.25.0/24	Origin: 37162	UNASSIGNED
41.76.25.0/24	Transit: 37012	ComSysGH-AS, GH
41.77.64.0/21	Origin: 37320	UNASSIGNED
41.77.64.0/21	Transit: 29614	GHANATEL-AS, GH
41.77.208.0/22	Origin: 37475	UNASSIGNED
41.77.208.0/22	Transit: 15964	CAMNET-AS, CM
41.77.240.0/21	Origin: 35251	NETLAB, CA
41.77.240.0/21	Transit: 8100	ASN-QUADRANET-GLOBAL, US
41.78.60.0/22	Origin: 6762	SEABONE-NET TELECOM ITALIA SPARKLE S.p.A
41.78.60.0/22	Transit: 2516	KDDI KDDI CORPORATION, JP
41.78.204.0/22	Origin: 37475	UNASSIGNED
41.78.204.0/22	Transit: 15964	CAMNET-AS, CM
41.79.128.0/22	Origin: 37475	UNASSIGNED
41.79.128.0/22	Transit: 15964	CAMNET-AS, CM
41.138.192.0/24	Origin: 20598	CYBERSPACE-AS Autonomous System number f
41.138.192.0/24	Transit: 37613	Dolphin-Telecom-AS, GH
41.191.240.0/21	Origin: 37103	UNASSIGNED
41.191.240.0/21	Transit: 37613	Dolphin-Telecom-AS, GH
41.191.240.0/24	Origin: 37103	UNASSIGNED
41.191.240.0/24	Transit: 37613	Dolphin-Telecom-AS, GH
41.191.241.0/24	Origin: 37103	UNASSIGNED
41.191.241.0/24	Transit: 37613	Dolphin-Telecom-AS, GH
41.191.242.0/24	Origin: 37103	UNASSIGNED
41.191.242.0/24	Transit: 37613	Dolphin-Telecom-AS, GH
41.191.243.0/24	Origin: 37103	UNASSIGNED
41.191.243.0/24	Transit: 37613	Dolphin-Telecom-AS, GH

## List of Unassigned IPv4 addresses

Far too many to list (over 600!!). See <http://thyme.apnic.net/current/data-add-IANA>:

Unassigned Network	ASN Information	AS Name
196.46.154.0/23	Origin: 28683	SBIN, BJ
196.46.154.0/23	Transit: 174	COGENT-174, US
196.50.21.0/24	Origin: 328149	UNASSIGNED
196.50.21.0/24	Transit: 37061	Safaricom, KE
196.52.0.0/24	Origin: 398252	BRC-YORKNE-01, US
196.52.0.0/24	Transit: 15164	UPNLLC, US
196.52.16.0/21	Origin: 18710	GKG-NET, US
196.52.16.0/21	Transit: 13876	FIBER-64, US
196.52.70.0/24	Origin: 32780	HOSTINGSERVICES-INC, US
196.52.70.0/24	Transit: 13213	UK2NET-AS, GB
196.53.30.0/24	Origin: 13213	UK2NET-AS, GB
196.53.30.0/24	Transit: 3257	GTT-BACKBONE GTT, US
196.53.64.0/24	Origin: 13213	UK2NET-AS, GB
196.53.64.0/24	Transit: 3257	GTT-BACKBONE GTT, US
196.53.113.0/24	Origin: 30277	DFW-DATACENTER, US
196.53.113.0/24	Transit: 393398	ASN-DIS, US
196.54.72.0/23	Origin: 26341	UNASSIGNED
196.54.72.0/23	Transit: 701	UUNET, US
196.63.128.0/19	Origin: 58931	LIHGL-AS-AP 24.hk global BGP, HK
196.63.128.0/19	Transit: 139646	HKMTC-AS-AP HONG KONG Megalayer Technolo
196.63.160.0/19	Origin: 58931	LIHGL-AS-AP 24.hk global BGP, HK
196.63.160.0/19	Transit: 139646	HKMTC-AS-AP HONG KONG Megalayer Technolo
196.195.4.0/24	Origin: 131284	ETISALATAFG-AS-AP Etisalat Afghan, AF
196.195.4.0/24	Transit: 38193	TWA-AS-AP Transworld Associates Pvt. Ltd
196.195.15.0/24	Origin: 131284	ETISALATAFG-AS-AP Etisalat Afghan, AF
196.195.15.0/24	Transit: 38193	TWA-AS-AP Transworld Associates Pvt. Ltd

## 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	/10:39	/11:103	/12:298	/13:578	/14:1196	/15:2050	/16:13461
/17:8245	/18:13834	/19:25155	/20:44224	/21:51231	/22:109545	/23:97693	/24:550516
/25:742	/26:0	/27:0	/28:0	/29:0	/30:0	/31:0	/32:0

22<sup>nd</sup> April 2023↑

22<sup>nd</sup> April 2022↓

/1:0	/2:0	/3:0	/4:0	/5:0	/6:0	/7:0	/8:16
/9:13	/10:41	/11:102	/12:307	/13:592	/14:1203	/15:2059	/16:13529
/17:8256	/18:13906	/19:25201	/20:43709	/21:52332	/22:108562	/23:96003	/24:530061
/25:831	/26:0	/27:0	/28:0	/29:0	/30:0	/31:0	/32:0

## Number of IPv6 prefixes announced by prefix length

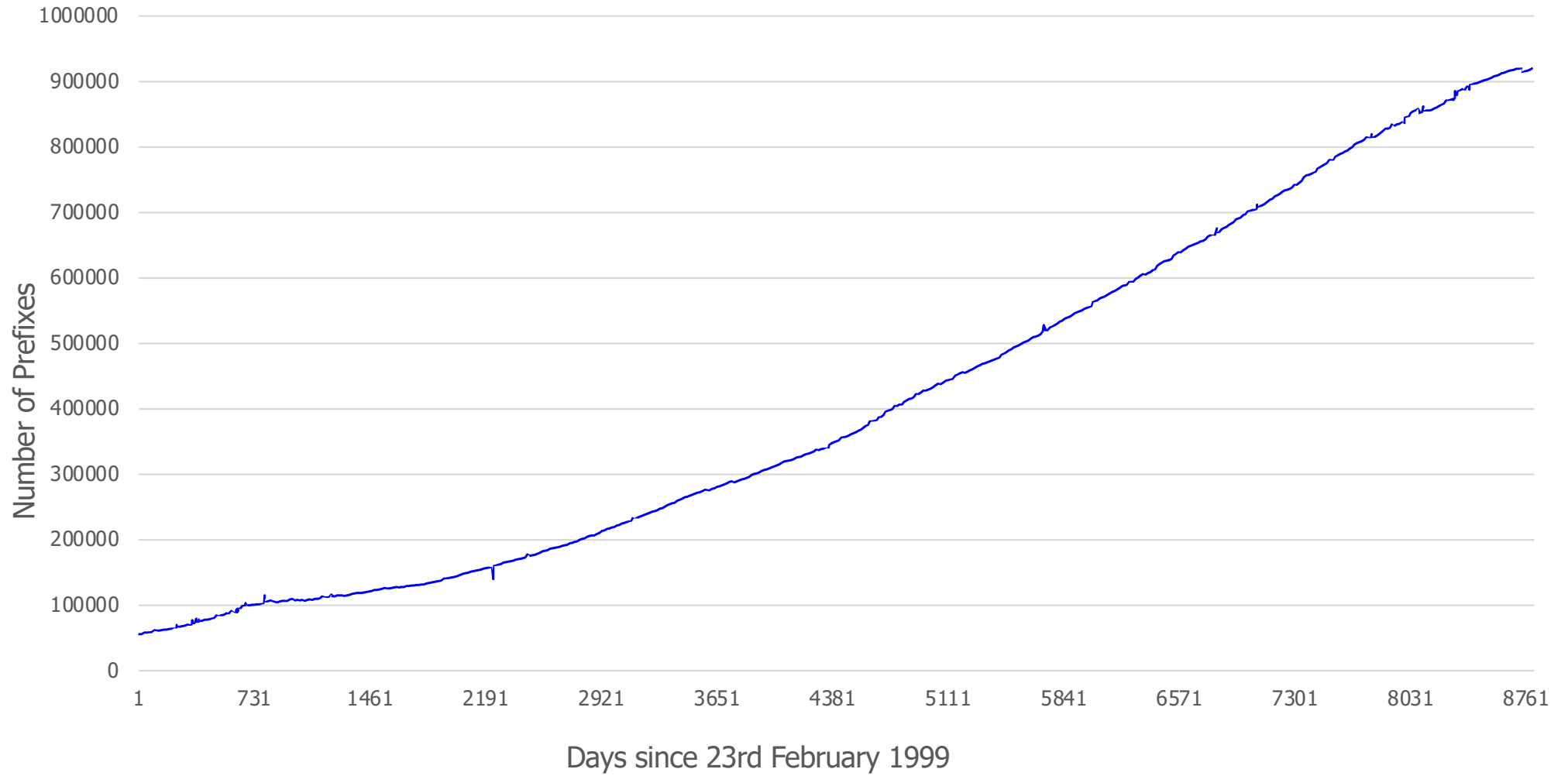
/16:1	/17:0	/18:0	/19:1	/20:14	/21:3	/22:7	/23:7
<del>/24:30</del>	/25:8	/26:16	/27:20	/28:197	/29:4322	/30:591	/31:304
<b>/32:22913</b>	/33:3063	/34:2617	/35:1066	/36:6153	/37:949	/38:1670	/39:1461
<del>/40:13913</del>	/41:930	/42:2445	/43:1044	/44:14914	/45:1748	/46:3116	/47:3587
<b>/48:84730</b>	/49 → /128: FILTERED by ISP						

22<sup>nd</sup> April 2023↑

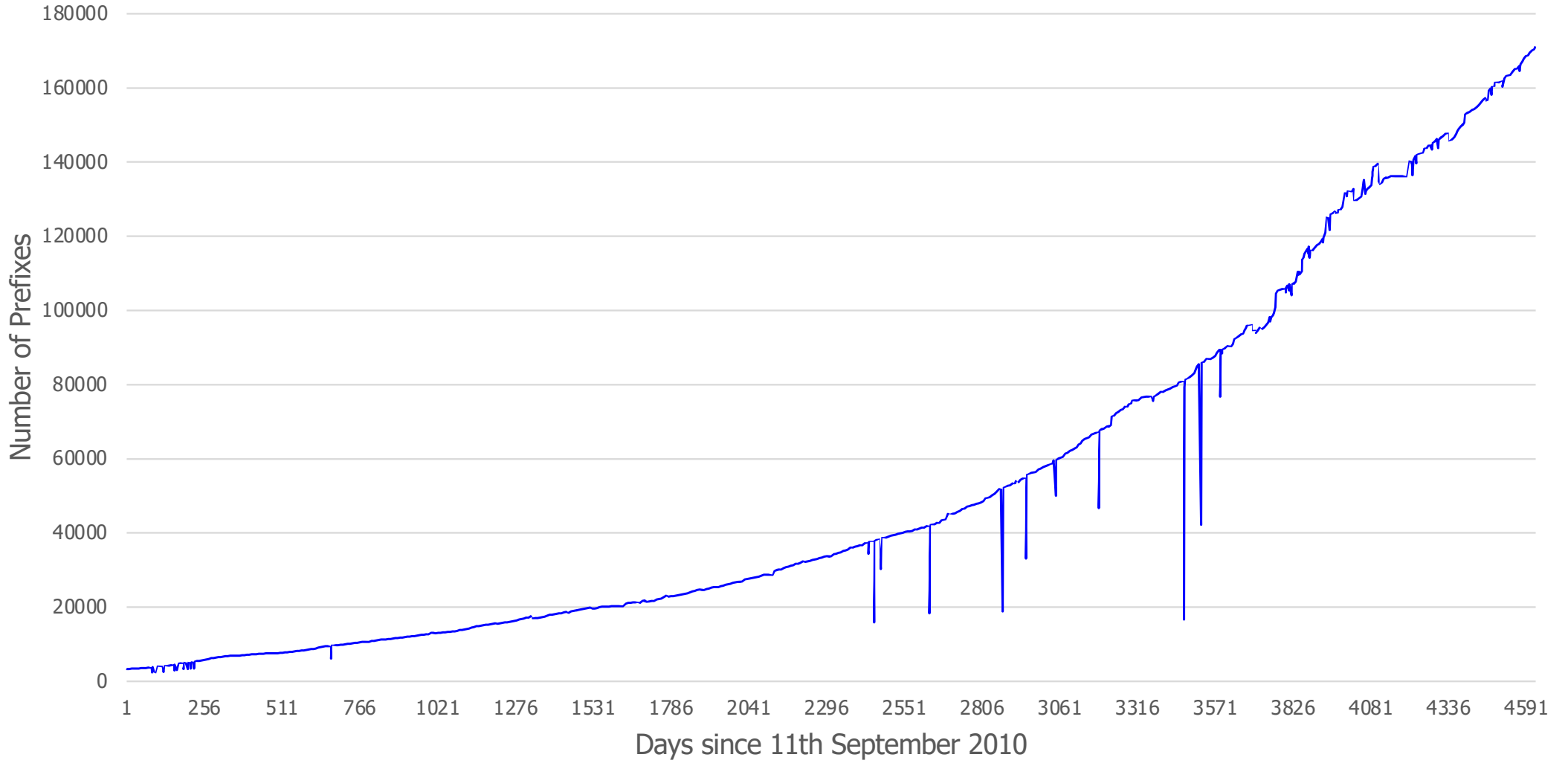
22<sup>nd</sup> April 2022↓

/16:1	/17:0	/18:0	/19:1	/20:15	/21:3	/22:7	/23:7
<del>/24:29</del>	/25:8	/26:15	/27:28	/28:188	/29:4151	/30:527	/31:217
<b>/32:21650</b>	/33:2588	/34:2260	/35:875	/36:5463	/37:928	/38:1651	/39:1248
<del>/40:11720</del>	/41:739	/42:2863	/43:1068	/44:11377	/45:1175	/46:2841	/47:2255
<b>/48:69600</b>	/49 → /128: FILTERED by ISP						

# Global IPv4 Routing Table

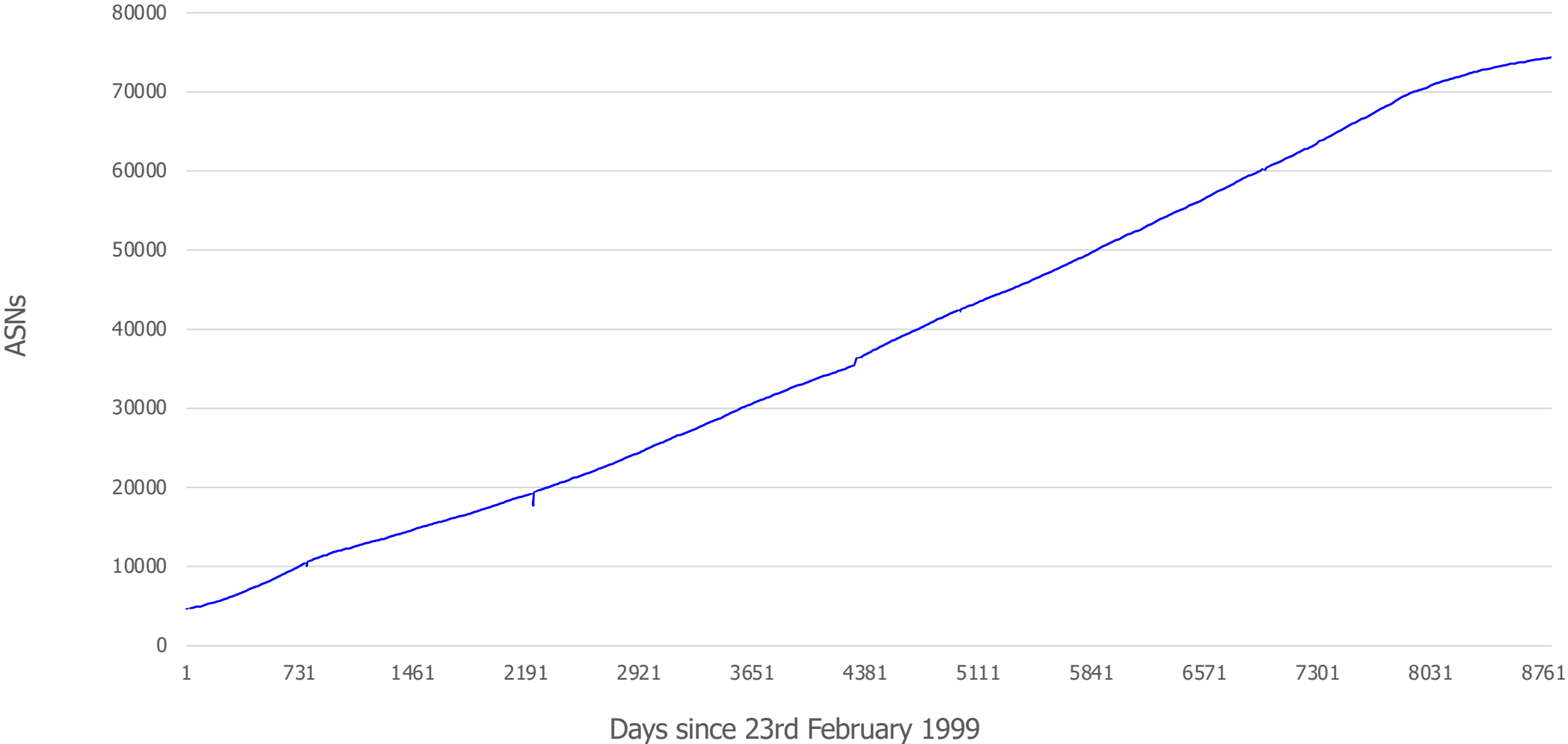


# Global IPv6 Routing Table

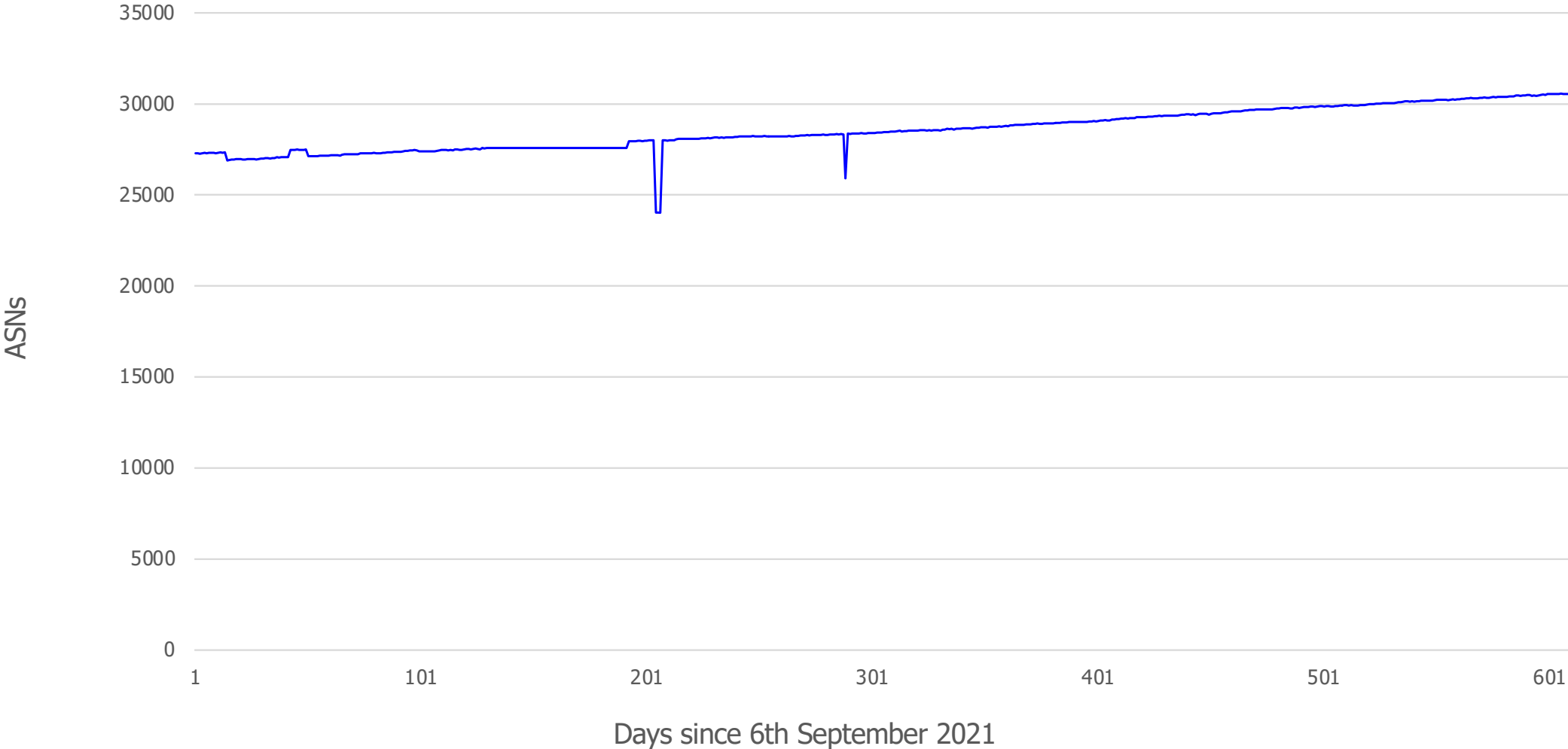




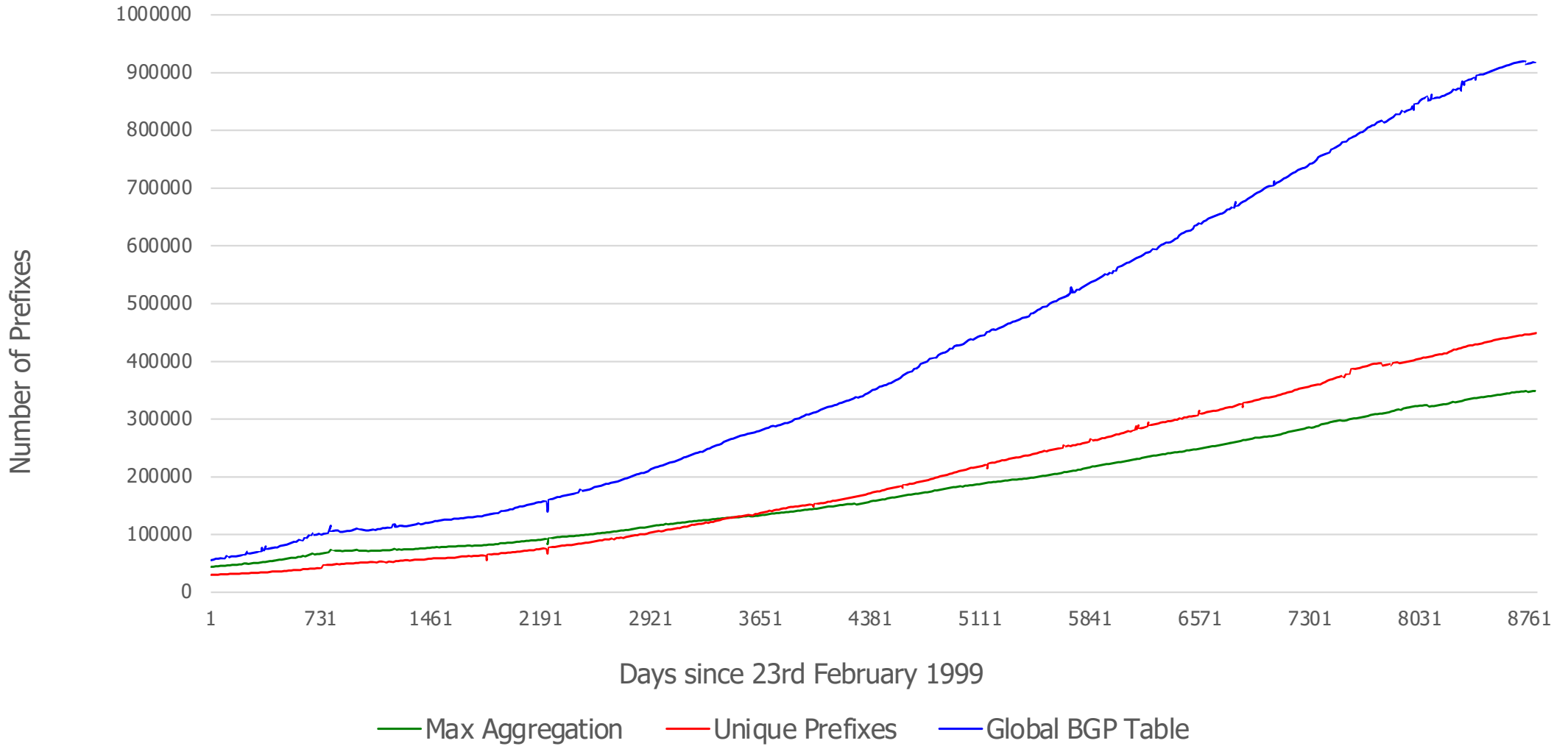
# AS Growth



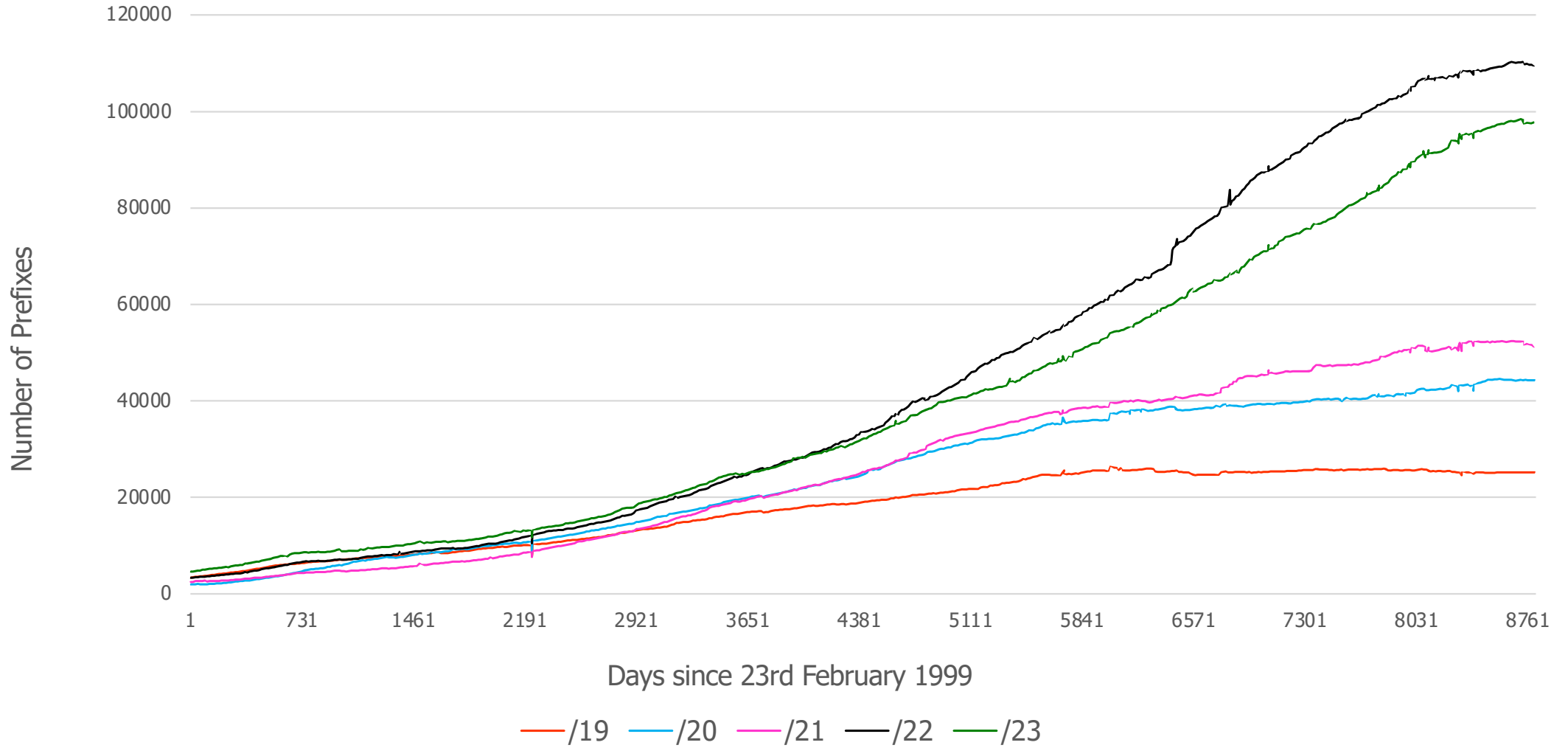
# IPv6 AS Growth



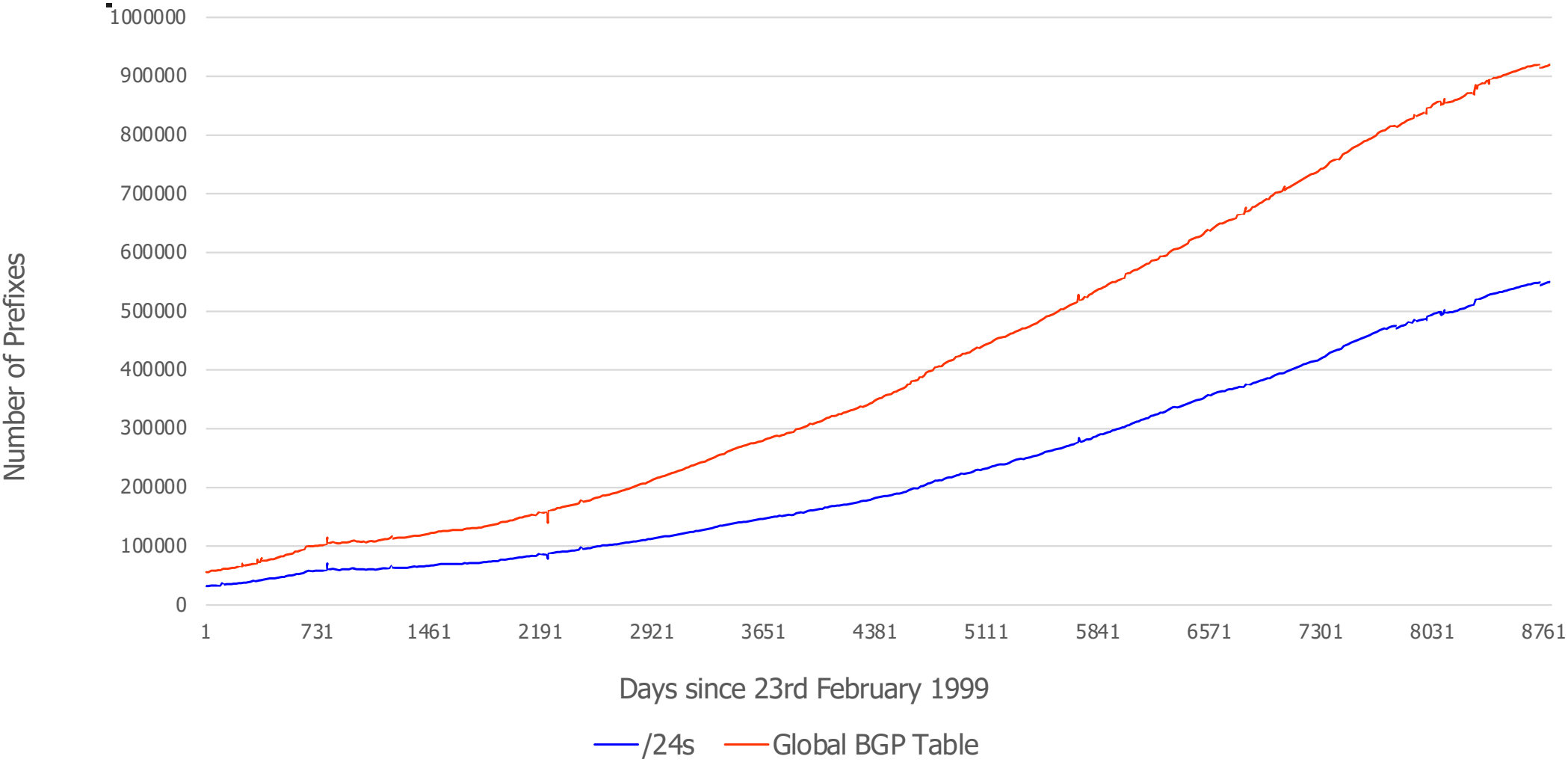
# IPv4 Max Aggregation vs Unique Prefixes



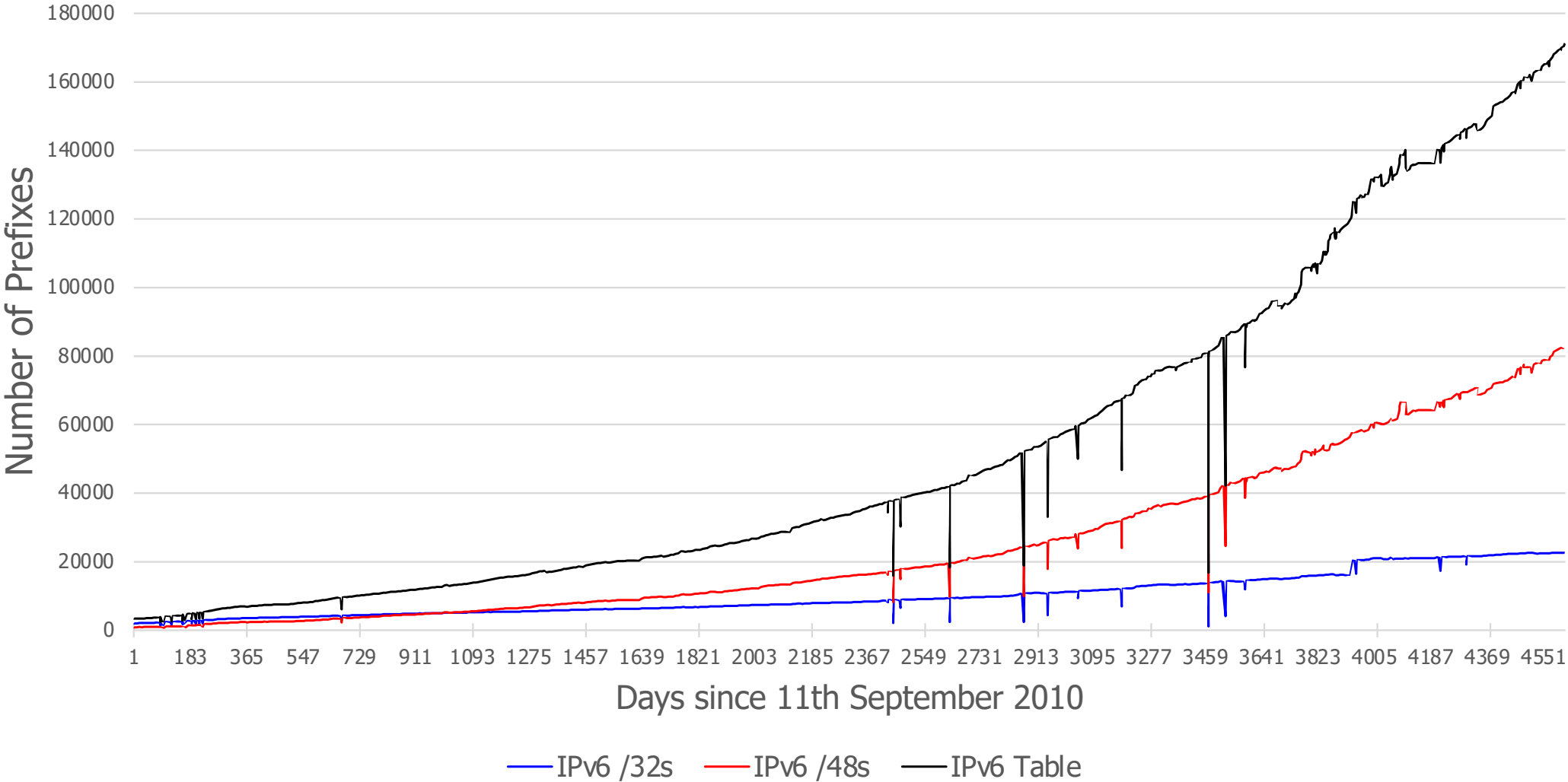
# IPv4 Prefix sizes announced



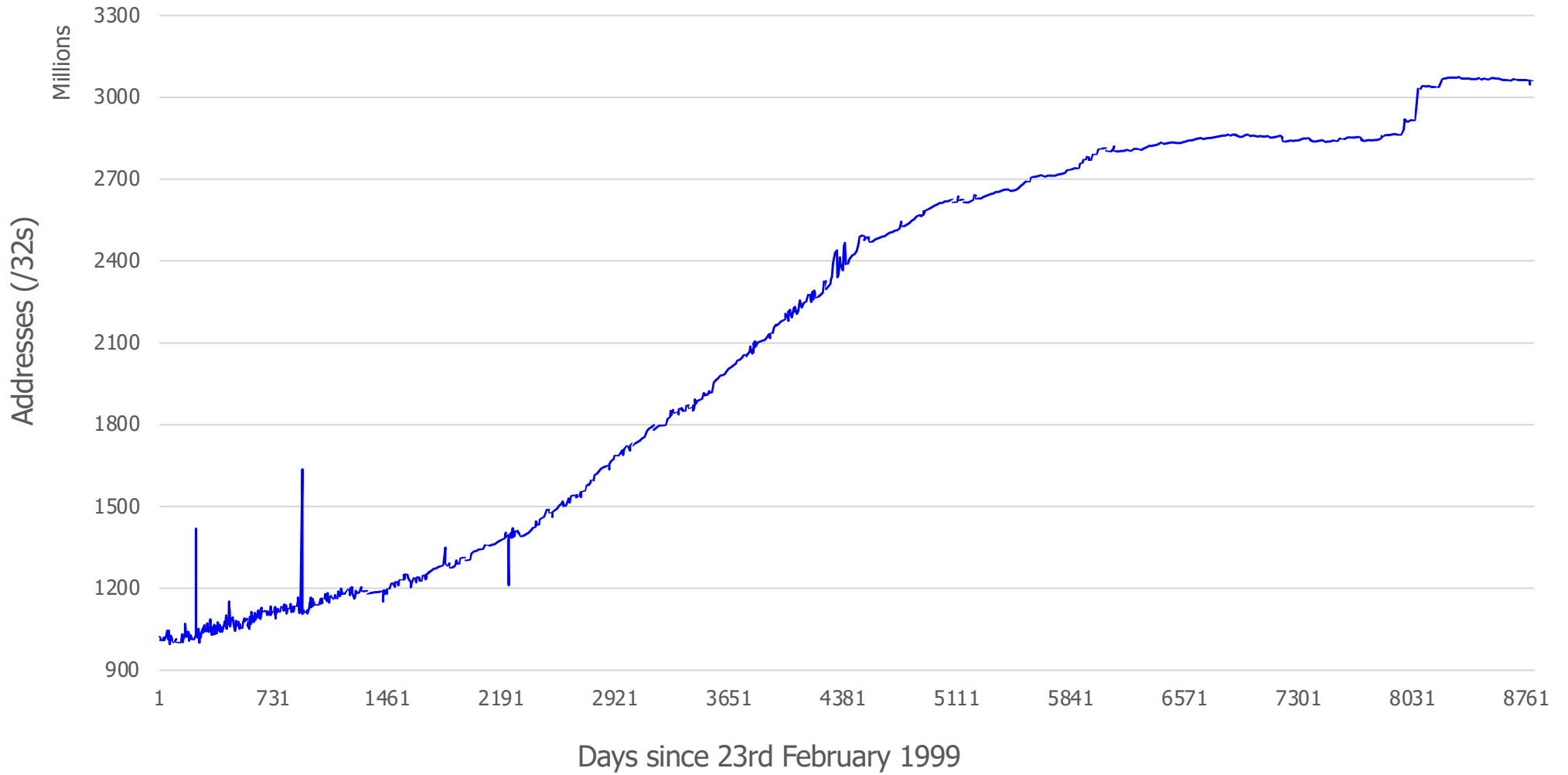
# IPv4 /24s announced



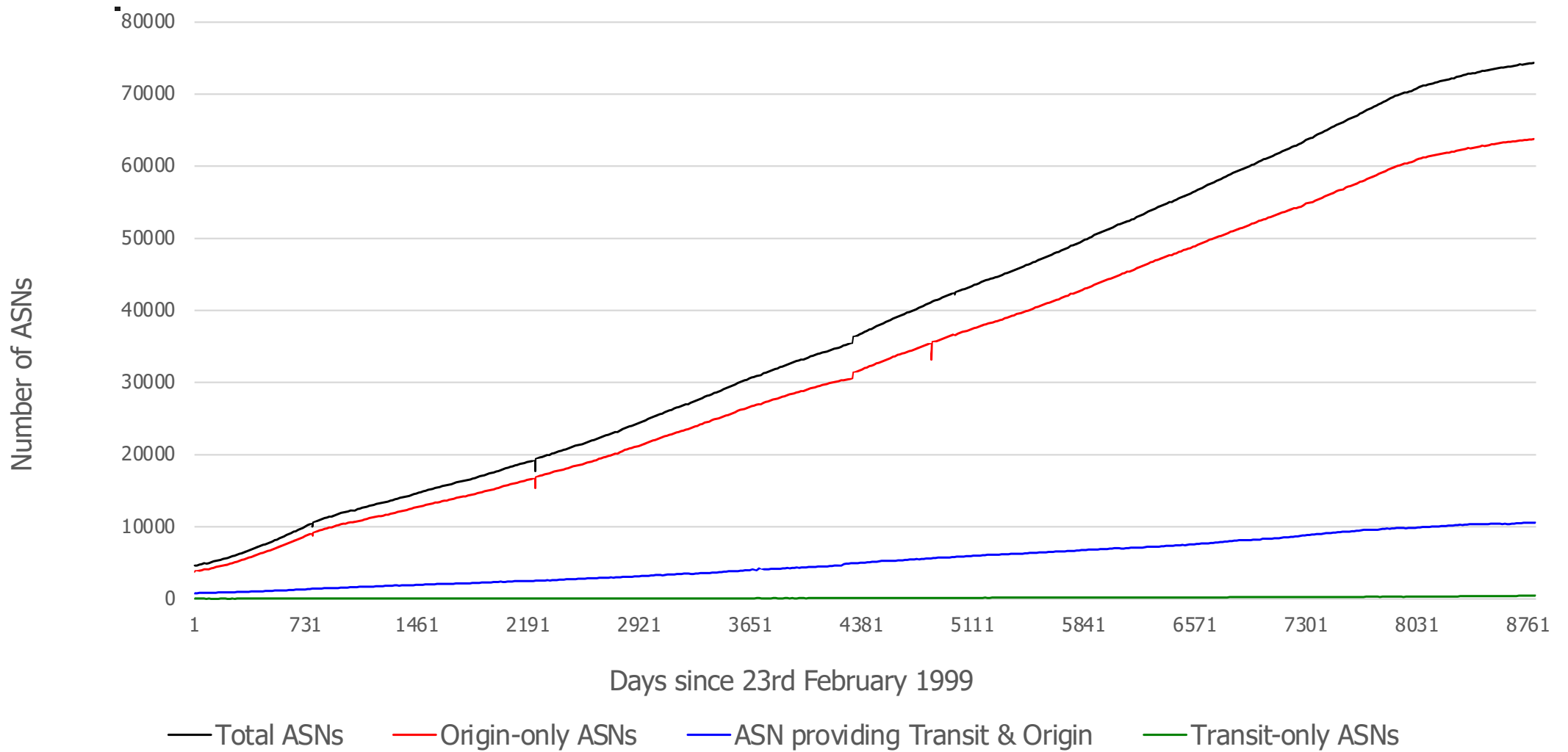
# IPv6 /32s vs /48s



# IPv4 Address Space announced

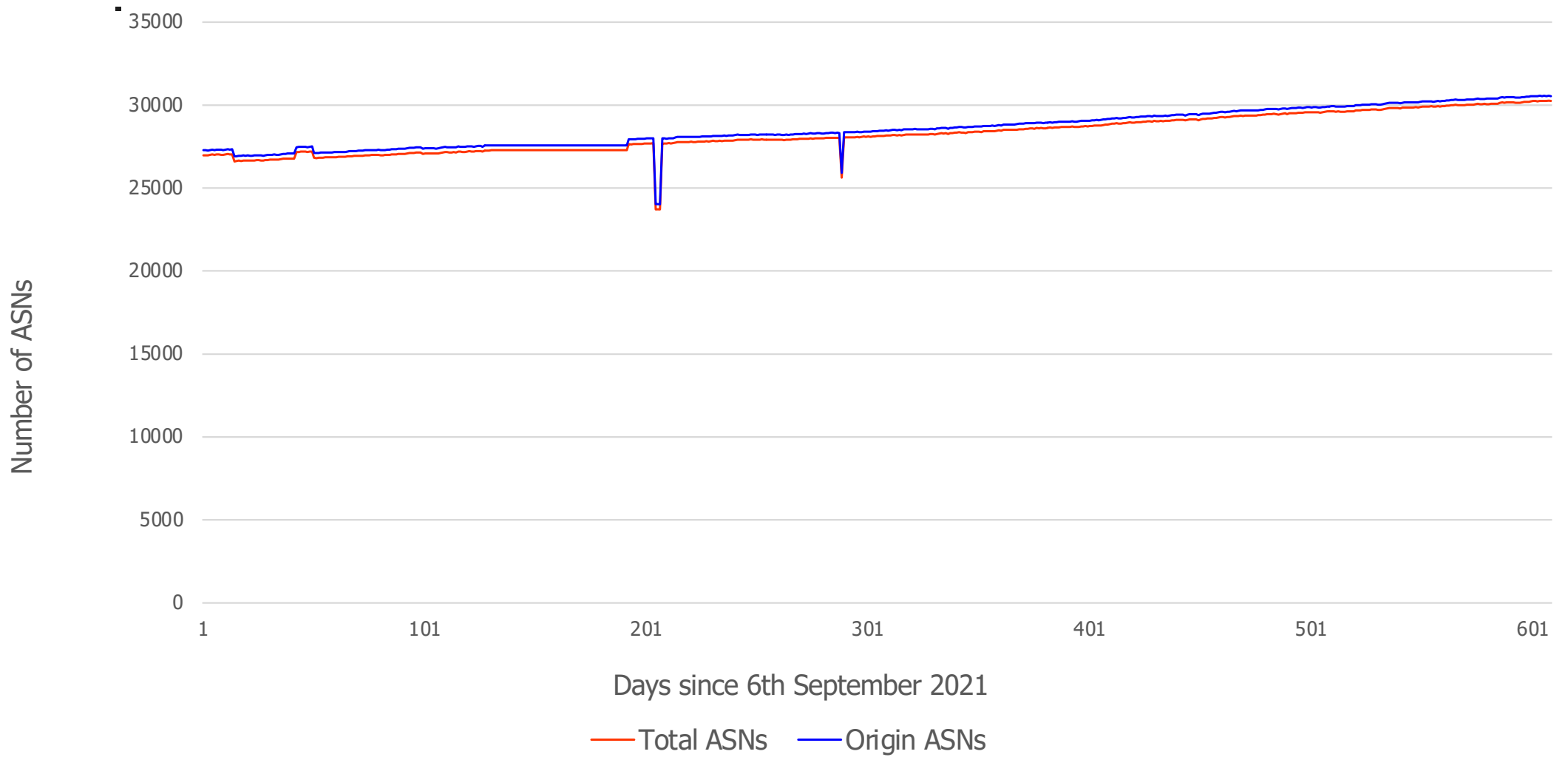


# IPv4 AS Announcements

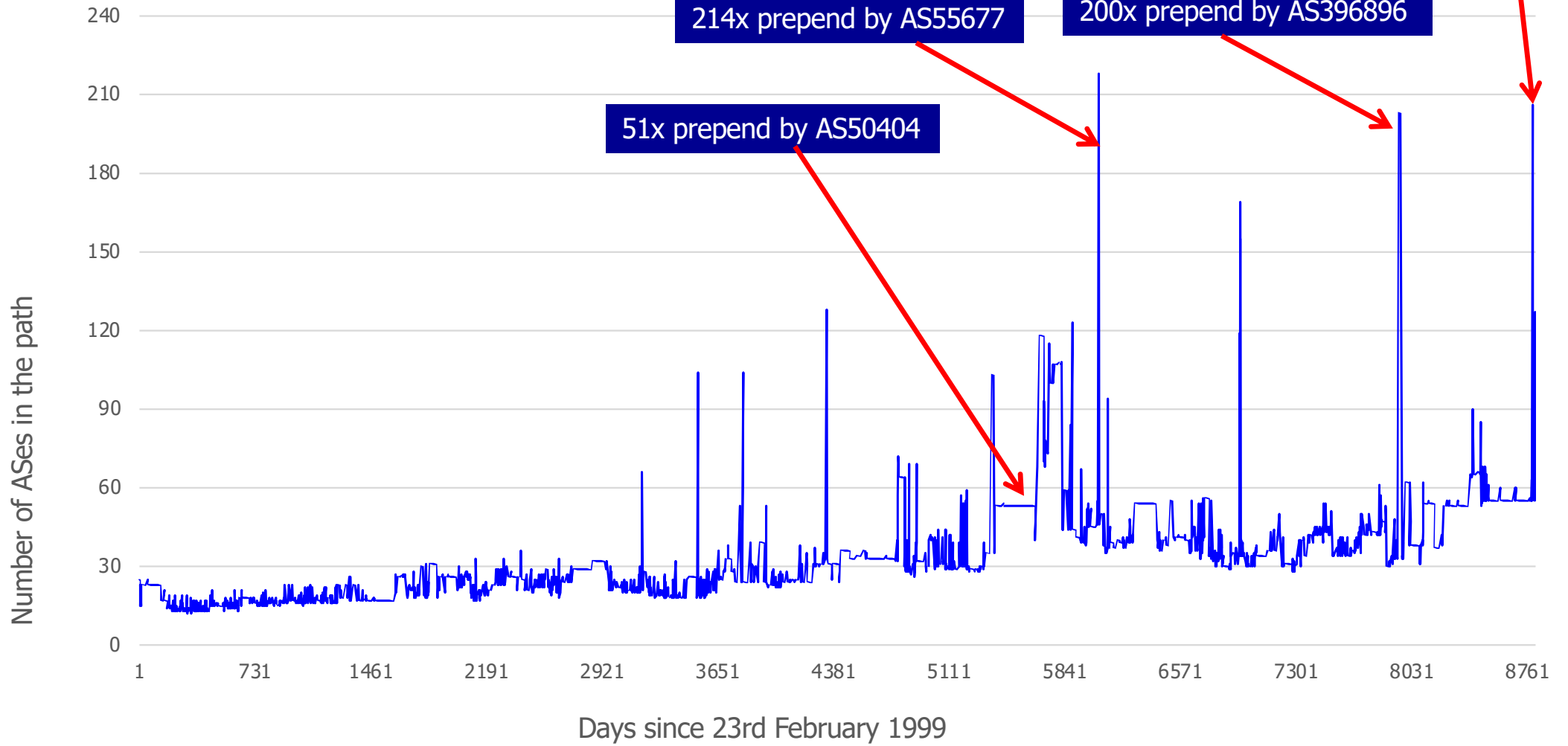




# IPv6 AS Announcements



# Maximum AS Path Length





# Looking at Deaggregation in IPv4

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- 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”



# April 2023

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- **Total Prefixes**

- Global BGP Table

- 919k prefixes

- North America

- 269k prefixes

- Europe & Middle East

- 259k prefixes

- Asia & Pacific

- 243k prefixes

- Latin America & Caribbean

- 118k prefixes

- Africa

- 29k prefixes

- **Deaggregation Factor**

- Global Average

- 2.63

- North America

- 2.20

- Europe & Middle East

- 2.12

- Asia & Pacific

- 3.50

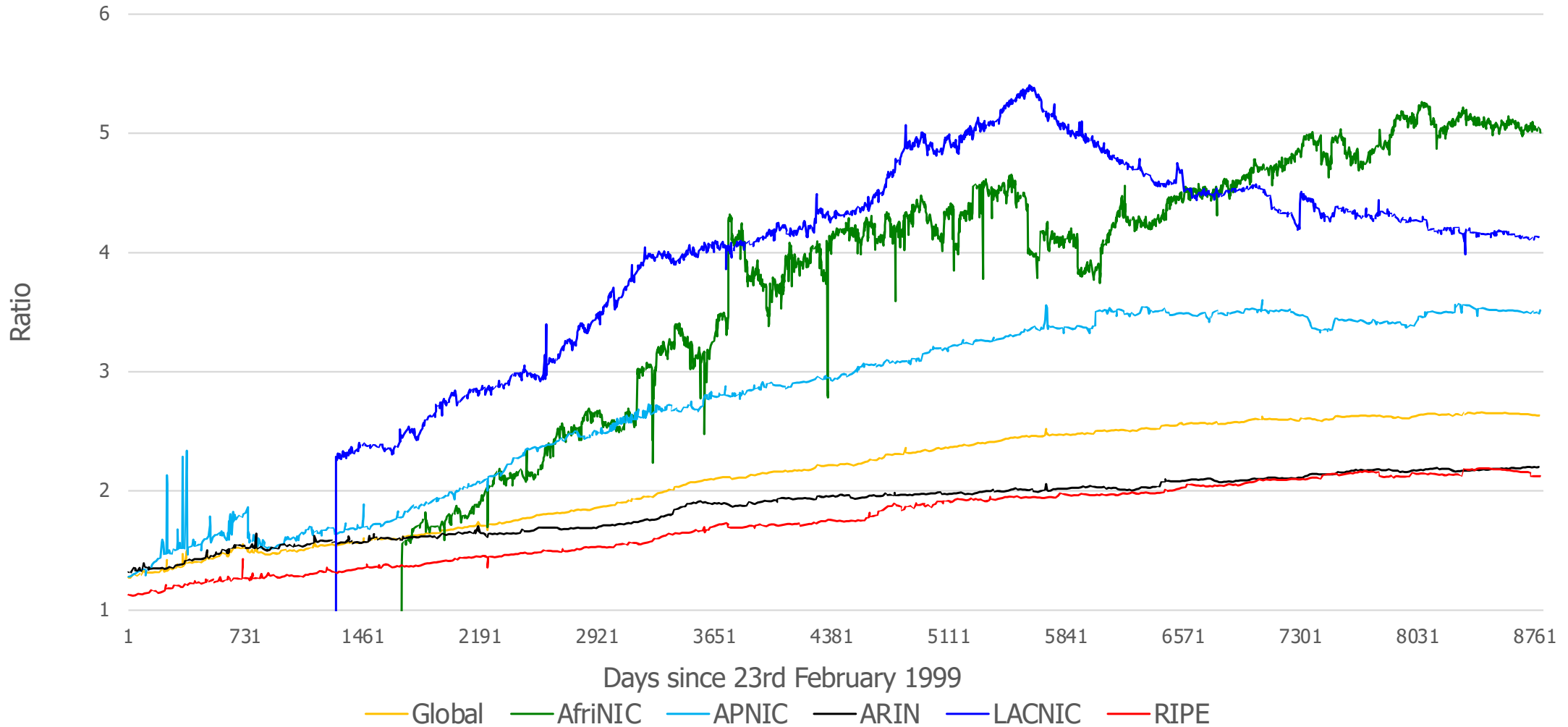
- Latin America & Caribbean

- 4.13

- Africa

- 5.03

# Deaggregation: RIR Regions vs Global



## Asia Pacific Aggregation Savings Summary

ASN	No of Nets	Savings	Description
9808	9486	9446	CHINAMOBILE-CN China Mobile Communications Grou
7545	5727	5033	TPG-INTERNET-AP TPG Telecom Limited, AU
4538	4863	4788	ERX-CERNET-BKB China Education and Research Net
45899	4054	4007	VNPT-AS-VN VNPT Corp, VN
7713	3560	3495	TELKOMNET-AS-AP PT Telekomunikasi Indonesia, ID
7552	3227	3206	VIETEL-AS-AP Viettel Group, VN
9498	2950	2714	BBIL-AP BHARTI Airtel Ltd., IN
18403	2302	2277	FPT-AS-AP FPT Telecom Company, VN
45090	2184	2105	TENCENT-NET-AP Shenzhen Tencent Computer System
4755	2181	1985	TATACOMM-AS TATA Communications formerly VSNL i
4766	2551	1960	KIXS-AS-KR Korea Telecom, KR
24560	2385	1939	AIRTELBROADBAND-AS-AP Bharti Airtel Ltd., Telem
23969	1925	1909	TOT-NET TOT Public Company Limited, TH
9829	1918	1884	BSNL-NIB National Internet Backbone, IN
45609	1894	1555	BHARTI-MOBILITY-AS-AP Bharti Airtel Ltd. AS for
56047	1508	1474	CMNET-HUNAN-AP China Mobile communications corp
56041	1457	1387	CMNET-ZHEJIANG-AP China Mobile communications c
56046	1415	1322	CMNET-JIANGSU-AP China Mobile communications co
9583	1767	1198	SIFY-AS-IN Sify Limited, IN
17488	1261	1148	HATHWAY-NET-AP Hathway IP Over Cable Internet,

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

## Afghanistan Aggregation Savings Summary

ASN	No of Nets	Savings	Description
38742	69	55	AWCC-AS-AP Afghan Wireless Communication Compan
55330	69	52	GCN-DCN-AS AFGHANTELECOM GOVERNMENT COMMUNICATI
17411	44	38	IO-GLOBAL-AP Io Global Services Pvt. Limited, A
131284	49	37	ETISALATAFG-AS-AP Etisalat Afghan, AF
55424	33	23	INSTATELECOM-AS-AP Instatelecom Limited, AF
132471	27	20	MTNAFGHANISTAN-AS-AP MTNAFGHANISTAN, AF
45178	25	19	ROSHAN-AF Main Street, House No. 13 Wazir Akbar
138322	30	13	AWCC-AS-AP Afghan Wireless Communication Compan
133066	11	7	ANS-AS-AP Ariana Network Services Co, AF
134134	10	5	NORTHTELECOM-AF North Telecom, AF

## Bangladesh Aggregation Savings Summary

ASN	No of Nets	Savings	Description
23688	249	241	LINK3-TECH-AS-BD-AP Link3 Technologies Ltd., BD
23956	184	179	AMBERIT-BD-AS AmberIT Limited, BD
24342	150	145	BRAC-BDMAIL-AS-BD BRACNet Limited, BD
17806	106	103	MANGOTELESERVICE-AS-BD Tire-1 IP Transit Provid
58715	123	101	EARTHTELECOMMUNICATION-AS EARTH TELECOMMUNICATI
23923	105	97	AGNI-AS Agni Systems Limited, BD
7565	84	82	BDCOM-BD Rangs Nilu Square, 5th Floor, House 75
17469	90	81	ACCESSTEL-AS-AP Access Telecom BD Ltd., BD
9230	84	79	BOL-BD-AP Bangladesh Online Ltd., BD
24323	92	77	AAMRA-NETWORKS-AS-AP aamra networks limited, BD

## India Aggregation Savings Summary

ASN	No of Nets	Savings	Description
9498	2950	2714	BBIL-AP BHARTI Airtel Ltd., IN
4755	2181	1985	TATACOMM-AS TATA Communications formerly VSNL i
24560	2385	1939	AIRTELBROADBAND-AS-AP Bharti Airtel Ltd., Telem
9829	1918	1884	BSNL-NIB National Internet Backbone, IN
45609	1894	1555	BHARTI-MOBILITY-AS-AP Bharti Airtel Ltd. AS for
9583	1767	1198	SIFY-AS-IN Sify Limited, IN
17488	1261	1148	HATHWAY-NET-AP Hathway IP Over Cable Internet,
55410	910	881	VIL-AS-AP Vodafone Idea Ltd, IN
45820	945	845	TTSL-MEISISP Tata Teleservices ISP AS, IN
38266	759	714	VIL-AS-AP Vodafone Idea Ltd, IN

## Sri Lanka Aggregation Savings Summary

ASN	No of Nets	Savings	Description
9329	131	120	SLTINT-AS-AP Sri Lanka Telecom Internet, LK
18001	76	62	DIALOG-AS Dialog Axiata PLC., LK
132045	63	58	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
45356	25	18	MOBITEL-LK Mobitel Pvt Ltd, LK
17470	16	13	HUTCHISON-LK Hutchison Telecommunications Lanka
132447	10	8	HUTCHISON-LK 234, Galle Road, Colombo 4, LK
38229	8	6	LEARN-LK Lanka Education & Research Network, NR



## Nepal Aggregation Savings Summary

ASN	No of Nets	Savings	Description
45899	4054	4007	VNPT-AS-VN VNPT Corp, VN
17501	219	208	WLINK-NEPAL-AS-AP WorldLink Communications Pvt
23752	108	102	NPTELECOM-NP-AS Nepal Telecommunications Corpor
4007	78	66	SUBISU-CABLENET-AS-AP Subisu Cablenet Pvt Ltd,
4613	70	64	MOS-NP Mercantile Office Systems, NP
38565	61	57	NCELL-AS-NP Ncell Pvt. Ltd., NP
24550	57	51	WEBSURFERNP-AS-NP Websurfer Nepal Internet Serv
45650	45	29	VIANET-NP Vianet Communications Pvt. Ltd., NP
55915	33	25	CLASSIC-NP Classic Tech Pvt. Ltd., NP
139922	26	16	SMNPL-AS-AP Simple Media Network Private Limite

## Pakistan Aggregation Savings Summary

ASN	No of Nets	Savings	Description
17557	1025	989	PKTELECOM-AS-PK Pakistan Telecommunication Comp
23674	495	470	NAYATEL-PK Nayatel Pvt Ltd, PK
9541	562	464	CYBERNET-AP Cyber Internet Services Pvt Ltd., P
132165	368	319	CONNECT-AS-AP Connect Communications, PK
45669	320	313	MOBILINK-AS-PK PMCL LDI IP TRANSIT, PK
59257	227	215	CMPAKLIMITED-AS-AP CMPak Limited, PK
58895	210	154	EBONE1-PK Ebone Network PVT. Limited, PK
23966	163	151	LDN-AS-PK LINKdotNET Telecom Limited, PK
38264	209	147	WATEEN-IMS-PK-AS-AP National WiMAXIMS environme
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
24016	52	49	RAAJJEONLINE-AS Focus Infocom Private Limited,
55944	48	44	OOREDOO-MV Ooredoo Maldives Plc, MV
136238	6	2	SATLINKPVT LTD-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	3	1	SUPERNET1-AS-AP SuperNet Infocomm, BT



# IPv4 Observations

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- 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

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- 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

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Questions?