

Internet IPv4 Routing Table Analysis Update



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SANOG 32

8th August 2018

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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 reporting report started 23rd February 1999:
 - Routing table size
 - CIDR-Report style reporting on a per-RIR basis
 - ...and many other interesting features

Routing Report 8th August 2018

BGP routing table entries examined:	709733
Prefixes after maximum aggregation (per Origin AS):	272563
Deaggregation factor:	2.60
Unique aggregates announced (without unneeded subnets):	340625
Total ASes present in the Internet Routing Table:	61442
Prefixes per ASN:	11.55
Origin-only ASes present in the Internet Routing Table:	53068
Origin ASes announcing only one prefix:	23120
Transit ASes present in the Internet Routing Table:	8374
Transit-only ASes present in the Internet Routing Table:	264
Average AS path length visible in the Internet Routing Table:	4.0
Max AS path length visible:	34
Max AS path prepend of ASN (30873)	32
Prefixes from unregistered ASNs in the Routing Table:	74
Number of instances of unregistered ASNs:	74
Number of 32-bit ASNs allocated by the RIRs:	23575
Number of 32-bit ASNs visible in the Routing Table:	19000
Prefixes from 32-bit ASNs in the Routing Table:	79466
Number of bogon 32-bit ASNs visible in the Routing Table:	37
Special use prefixes present in the Routing Table:	2
Prefixes being announced from unallocated address space:	285
Number of addresses announced to Internet:	2857443908
Equivalent to 170 /8s, 81 /16s and 34 /24s	
Percentage of available address space announced:	77.2
Percentage of allocated address space announced:	77.2
Percentage of available address space allocated:	100.0
Percentage of address space in use by end-sites:	99.0
Total number of prefixes smaller than registry allocations:	236669

APNIC Region

Prefixes being announced by APNIC Region ASes:	193803
Total APNIC prefixes after maximum aggregation:	55158
APNIC Deaggregation factor:	3.51
Prefixes being announced from the APNIC address blocks:	192037
Unique aggregates announced from the APNIC address blocks:	79084
APNIC Region origin ASes present in the Internet Routing Table:	8996
APNIC Prefixes per ASN:	21.35
APNIC Region origin ASes announcing only one prefix:	2532
APNIC Region transit ASes present in the Internet Routing Table:	1334
Average APNIC Region AS path length visible:	4.0
Max APNIC Region AS path length visible:	29
Number of APNIC region 32-bit ASNs visible in the Routing Table:	3949
Number of APNIC addresses announced to Internet:	767417091
Equivalent to 45 /8s, 189 /16s and 219 /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, 131072-137529

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
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Global per AS prefix count summary

ASN	No of nets	/20 equiv	Max Agg	Description
8151	5188	3349	607	Uninet S.A. de C.V., MX
4538	4689	4192	74	ERX-CERNET-BKB China Education and Rese
12479	4673	1613	124	UNI2-AS, ES
7545	4397	477	468	TPG-INTERNET-AP TPG Telecom Limited, AU
39891	3778	203	20	ALJAWWALSTC-AS, SA
10620	3515	535	387	Telmex Colombia S.A., CO
6327	3440	1324	82	SHAW - Shaw Communications Inc., CA
22773	3249	2968	149	ASN-CXA-ALL-CCI-22773-RDC - Cox Communi
7552	2978	1153	83	VIETEL-AS-AP Viettel Group, VN
4766	2845	11134	767	KIXS-AS-KR Korea Telecom, KR
8551	2838	378	44	BEZEQ-INTERNATIONAL-AS Bezeqint Interne
9829	2813	1497	543	BSNL-NIB National Internet Backbone, IN
11492	2701	248	448	CABLEONE - CABLE ONE, INC., US
11830	2657	369	78	Instituto Costarricense de Electricidad
45899	2579	1630	156	VNPT-AS-VN VNPT Corp, VN
20940	2553	625	1890	AKAMAI-ASN1, US
9394	2537	4907	31	CTTNET China TieTong Telecommunications
17974	2262	964	72	TELKOMNET-AS2-AP PT Telekomunikasi Indo
16509	2255	4791	766	AMAZON-02 - Amazon.com, Inc., US
9808	2240	8699	26	CMNET-GD Guangdong Mobile Communication
18566	2167	405	109	MEGAPATH5-US - MegaPath Corporation, US
20115	2126	2644	486	CHARTER-NET-HKY-NC - Charter Communicat
4755	2115	433	206	TATACOMM-AS TATA Communications formerl
12389	2042	1891	731	ROSTELECOM-AS, RU

AfriNIC APNIC ARIN LACNIC RIPE NCC

List of Unregistered Origin ASNs (Global)

Bogon AS	Designation	Network	Transit AS	Description
230105	UNALLOCATED	38.110.79.0/24	23015	CMC180-TOR-AS - Cambridge Merc
266842	UNALLOCATED	45.238.156.0/22	265680	HNTELCO S.A, HN
4200015017	PRIVATE	47.74.136.0/24	45102	CNNIC-ALIBABA-CN-NET-AP Alibab
4200015017	PRIVATE	47.74.161.0/24	45102	CNNIC-ALIBABA-CN-NET-AP Alibab
4200015017	PRIVATE	47.74.203.0/24	45102	CNNIC-ALIBABA-CN-NET-AP Alibab
4200015017	PRIVATE	47.88.147.0/24	45102	CNNIC-ALIBABA-CN-NET-AP Alibab
65537	DOCUMENT	62.162.120.0/24	6821	MT-AS-OWN bul. Orce Nikolov bb
419333	UNALLOCATED	84.17.91.0/24	41933	IPRAGAZ-AS Istanbul/ TURKEY, T
4259905537	PRIVATE	103.250.48.0/24	132917	YELLOWPAGESGROUP-AS-AP Yellow
4259840000	PRIVATE	103.250.49.0/24	132917	YELLOWPAGESGROUP-AS-AP Yellow
4259840000	PRIVATE	103.250.51.0/24	132917	YELLOWPAGESGROUP-AS-AP Yellow
65536	DOCUMENT	128.75.229.0/24	3216	SOVAM-AS, RU
65536	DOCUMENT	128.75.231.0/24	3216	SOVAM-AS, RU
65536	DOCUMENT	128.75.233.0/24	3216	SOVAM-AS, RU
65550	DOCUMENT	160.155.253.0/24	29571	ORANGE-COTE-IVOIRE, CI
65550	DOCUMENT	160.155.255.0/24	29571	ORANGE-COTE-IVOIRE, CI
65566	UNALLOCATED	178.176.160.0/23	31133	MF-MGSM-AS PJSC MegaFon, RU
65566	UNALLOCATED	178.176.164.0/24	31133	MF-MGSM-AS PJSC MegaFon, RU
65566	UNALLOCATED	178.176.166.0/24	31133	MF-MGSM-AS PJSC MegaFon, RU
65566	UNALLOCATED	178.176.168.0/24	31133	MF-MGSM-AS PJSC MegaFon, RU
65566	UNALLOCATED	178.176.170.0/24	31133	MF-MGSM-AS PJSC MegaFon, RU
65566	UNALLOCATED	178.176.172.0/24	31133	MF-MGSM-AS PJSC MegaFon, RU
...etc...				
327074	UNALLOCATED	196.216.227.0/24	36974	AFNET-AS, CI
100001	UNALLOCATED	200.142.187.0/24	100000	UNKNOWN
65817	UNALLOCATED	202.75.201.0/24	703	UUNET - MCI Communications Ser

Number of prefixes announced by prefix length

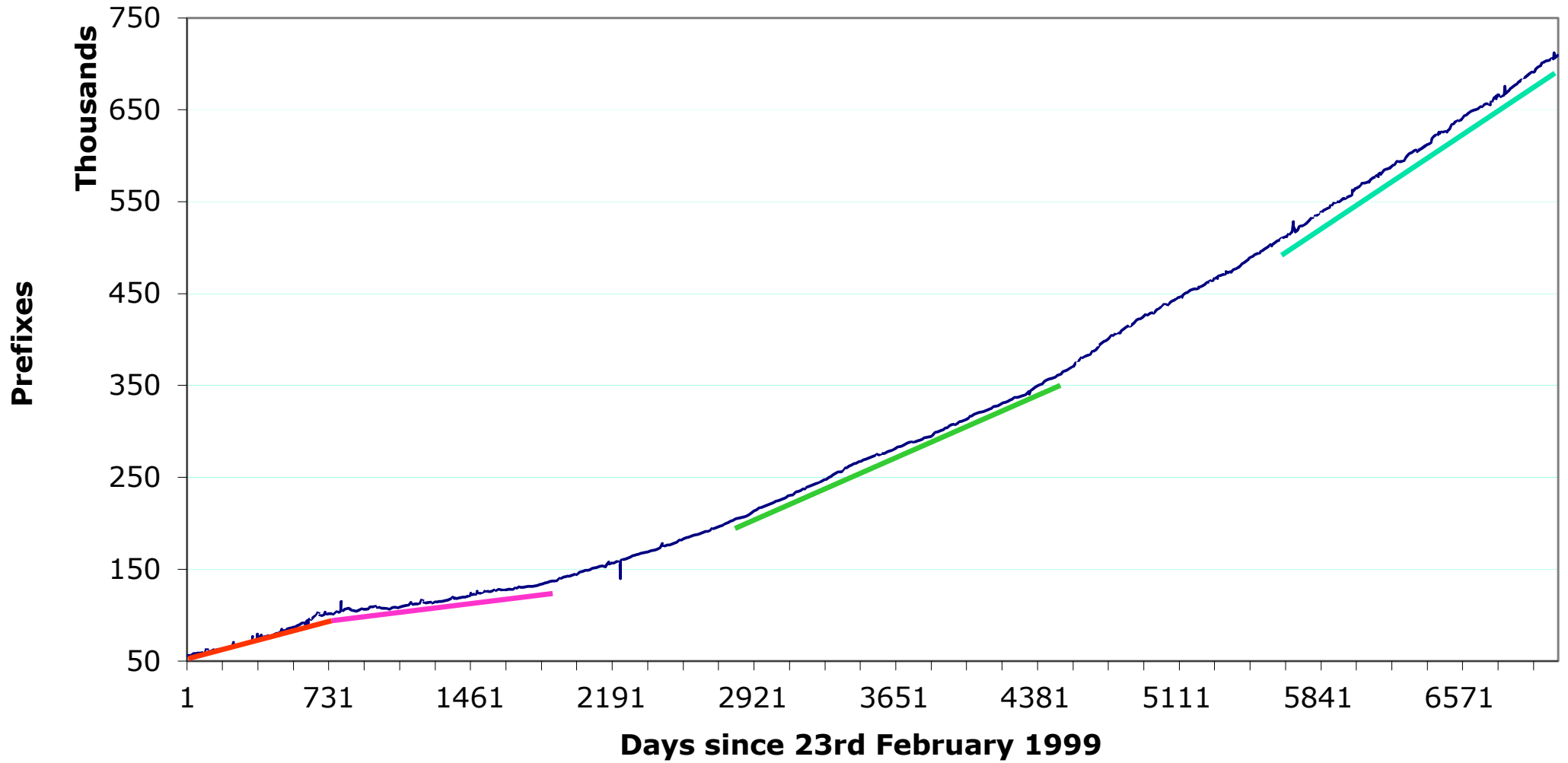
/1:0	/2:0	/3:0	/4:0	/5:0	/6:0	/7:0	/8:14
/9:11	/10:36	/11:99	/12:291	/13:569	/14:1096	/15:1897	/16:13378
/17:7929	/18:13801	/19:25380	/20:39396	/21:45733	/22:87968	/23:71543	/24:398428
/25:800	/26:606	/27:627	/28:35	/29:20	/30:19	/31:4	/32:53

8th August 2018 ↑

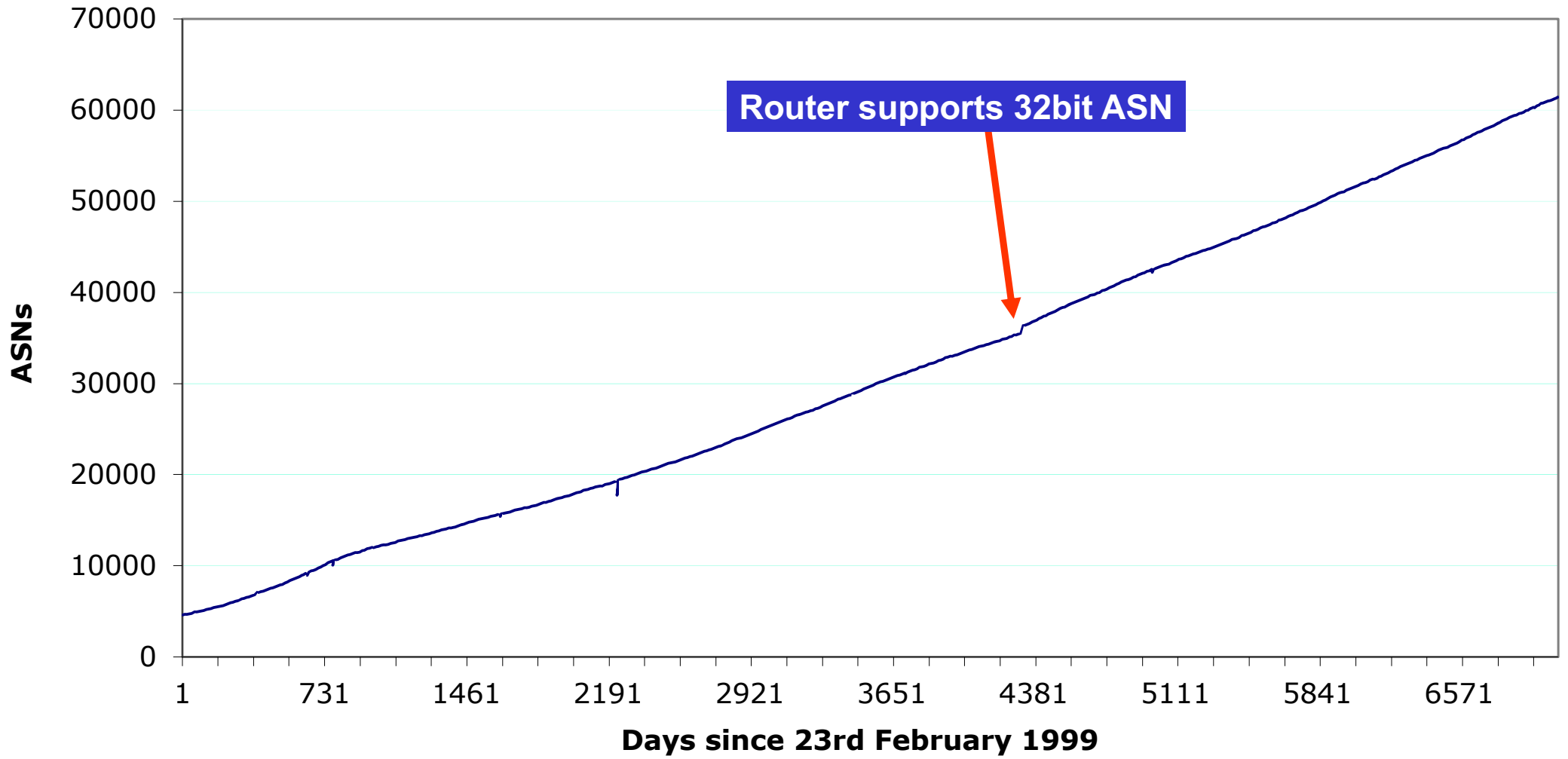
8th August 2017 ↓

/1:0	/2:0	/3:0	/4:0	/5:0	/6:0	/7:0	/8:15
/9:13	/10:36	/11:104	/12:284	/13:553	/14:1050	/15:1852	/16:13448
/17:7629	/18:13397	/19:24671	/20:38911	/21:41551	/22:78213	/23:64844	/24:367295
/25:878	/26:630	/27:638	/28:37	/29:25	/30:18	/31:2	/32:28

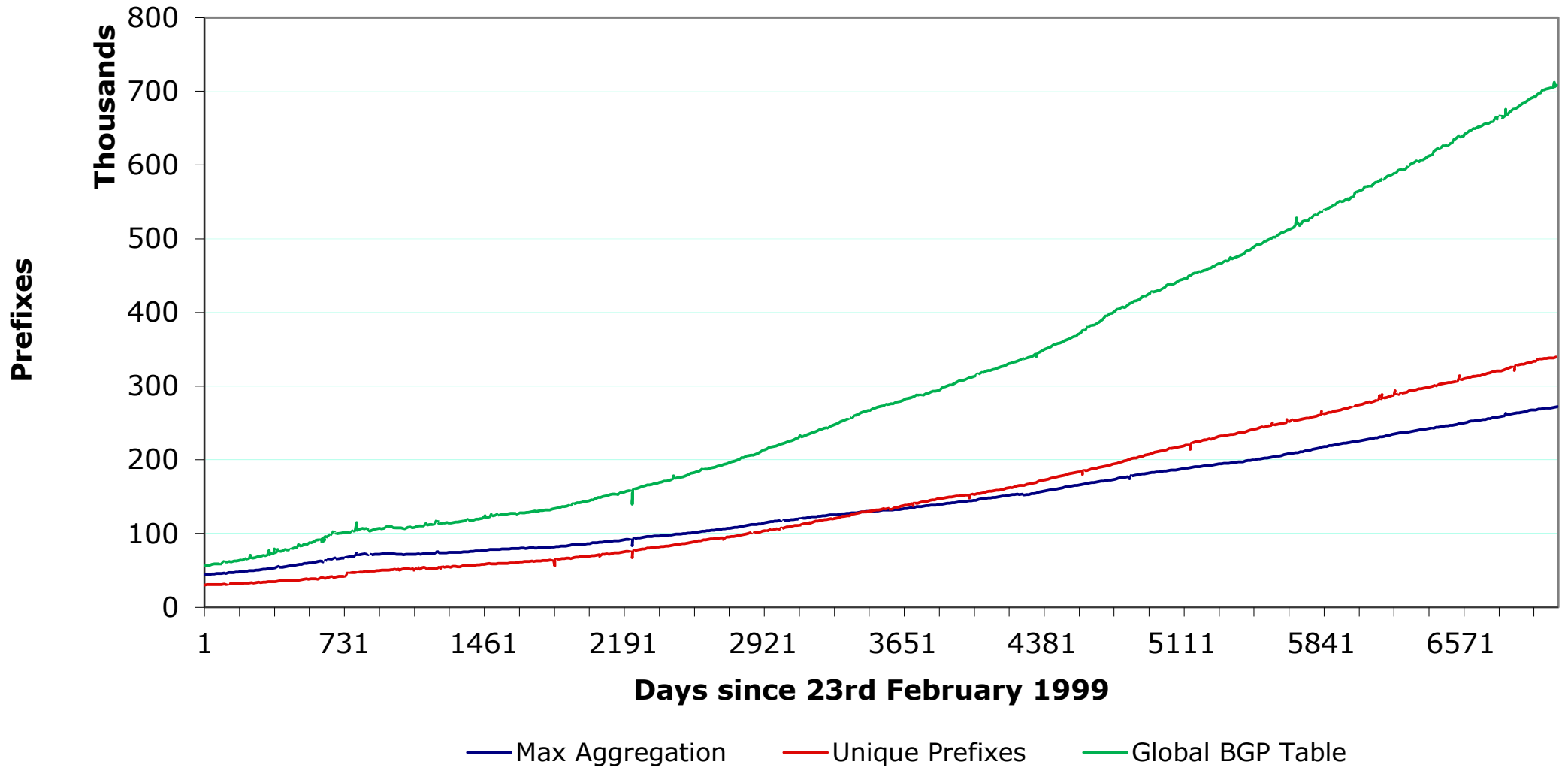
Global IPv4 Routing Table



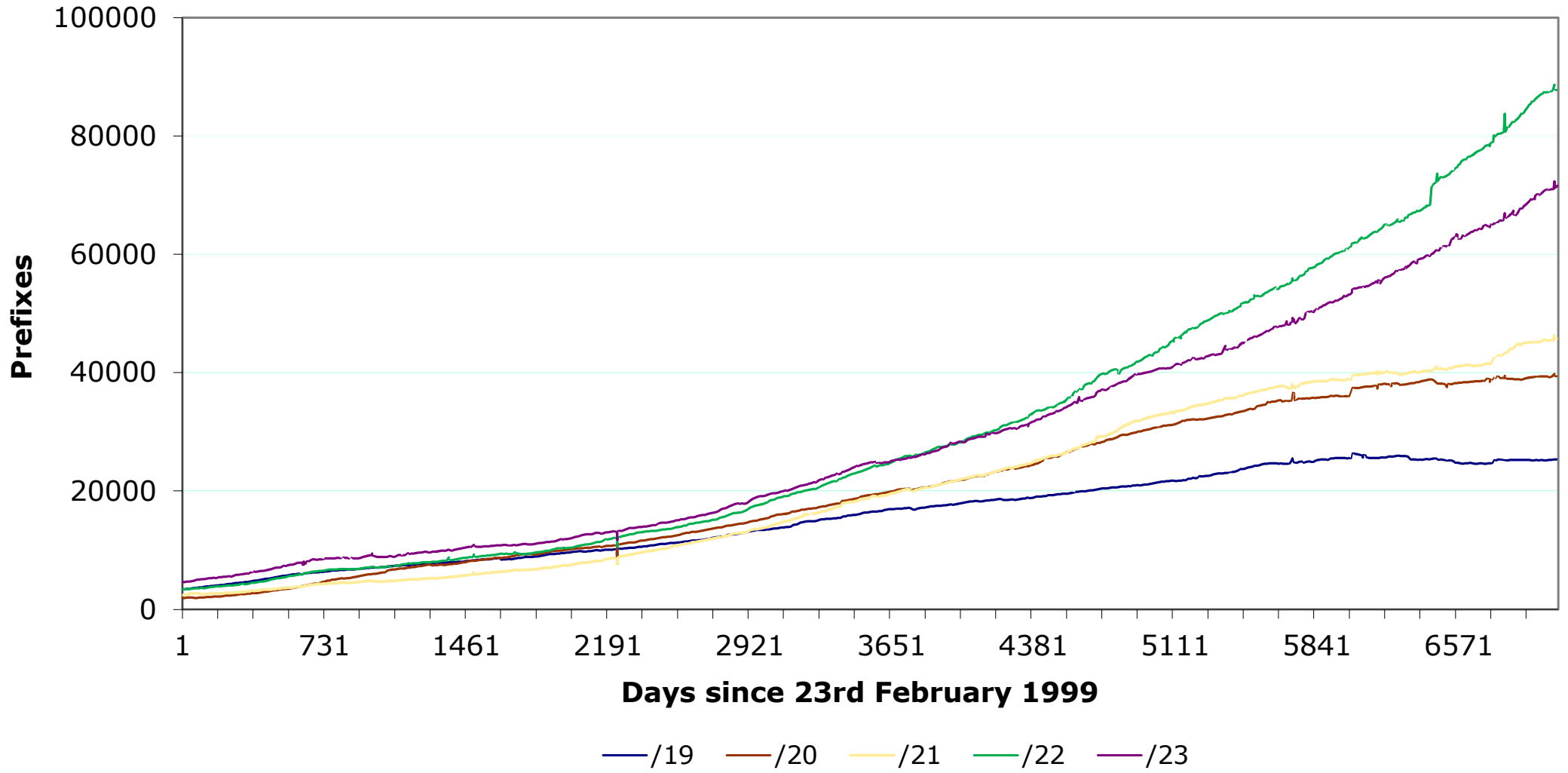
AS Growth



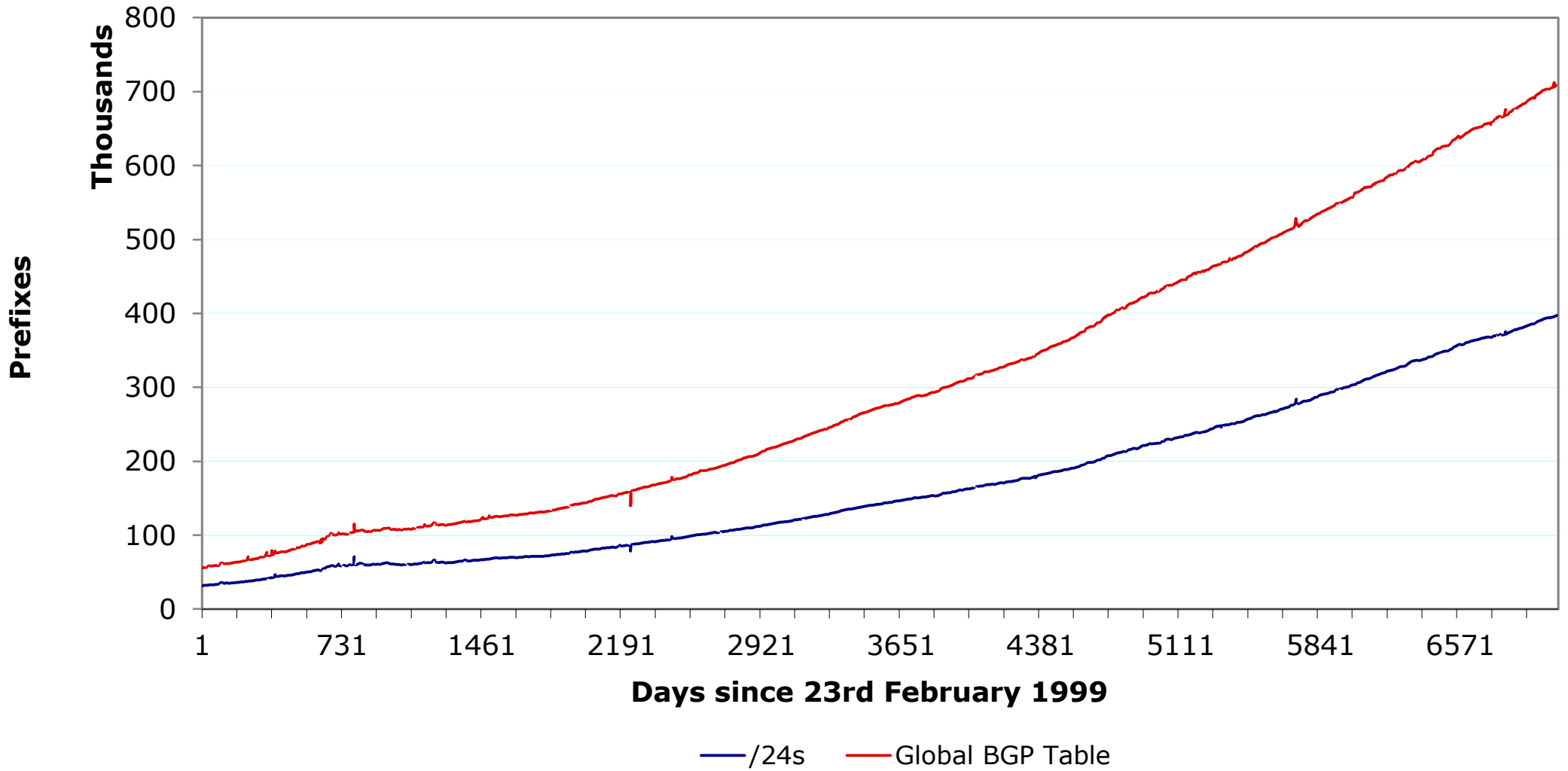
Max Aggregation vs Unique Prefixes



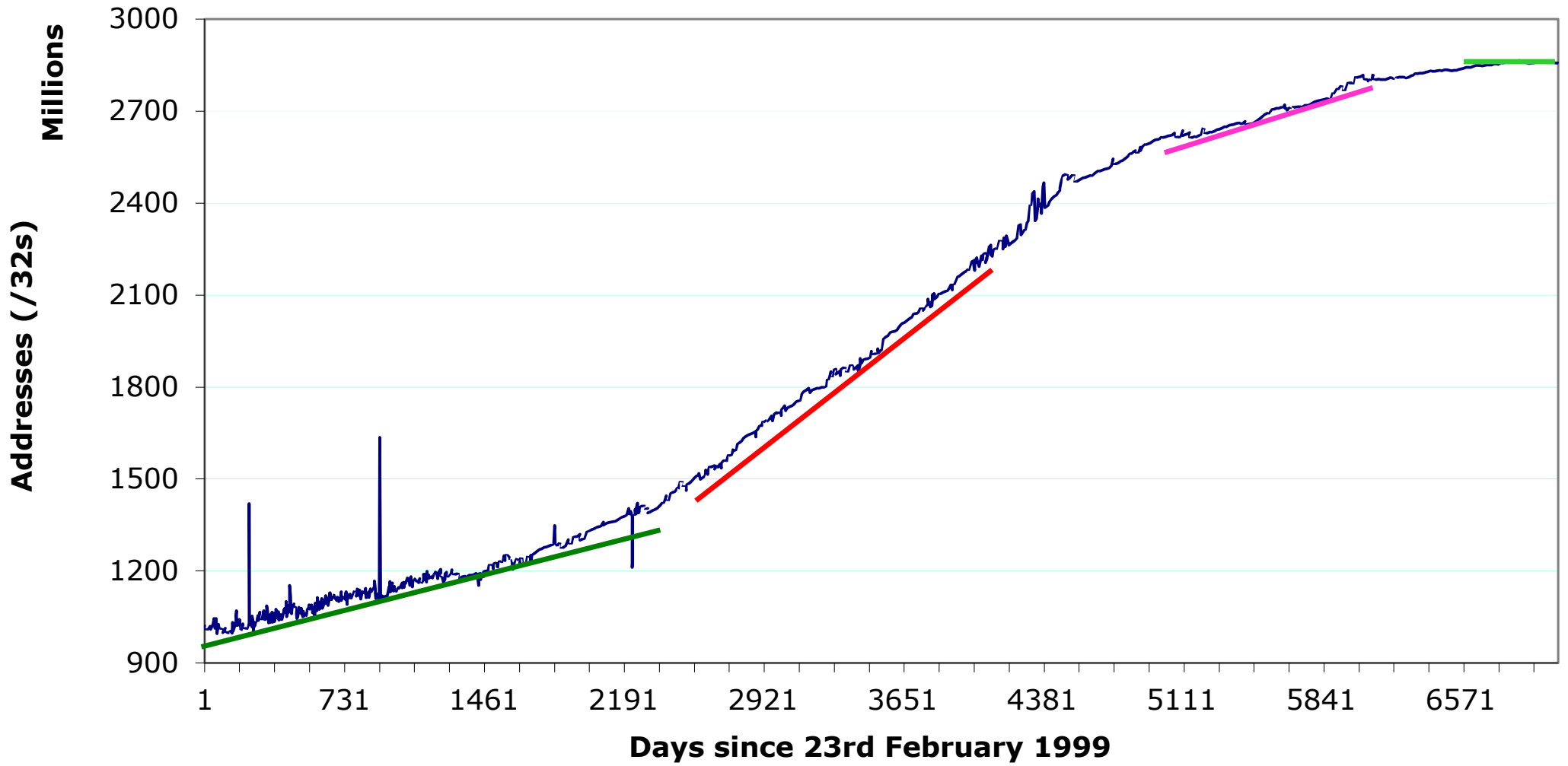
Prefix sizes announced



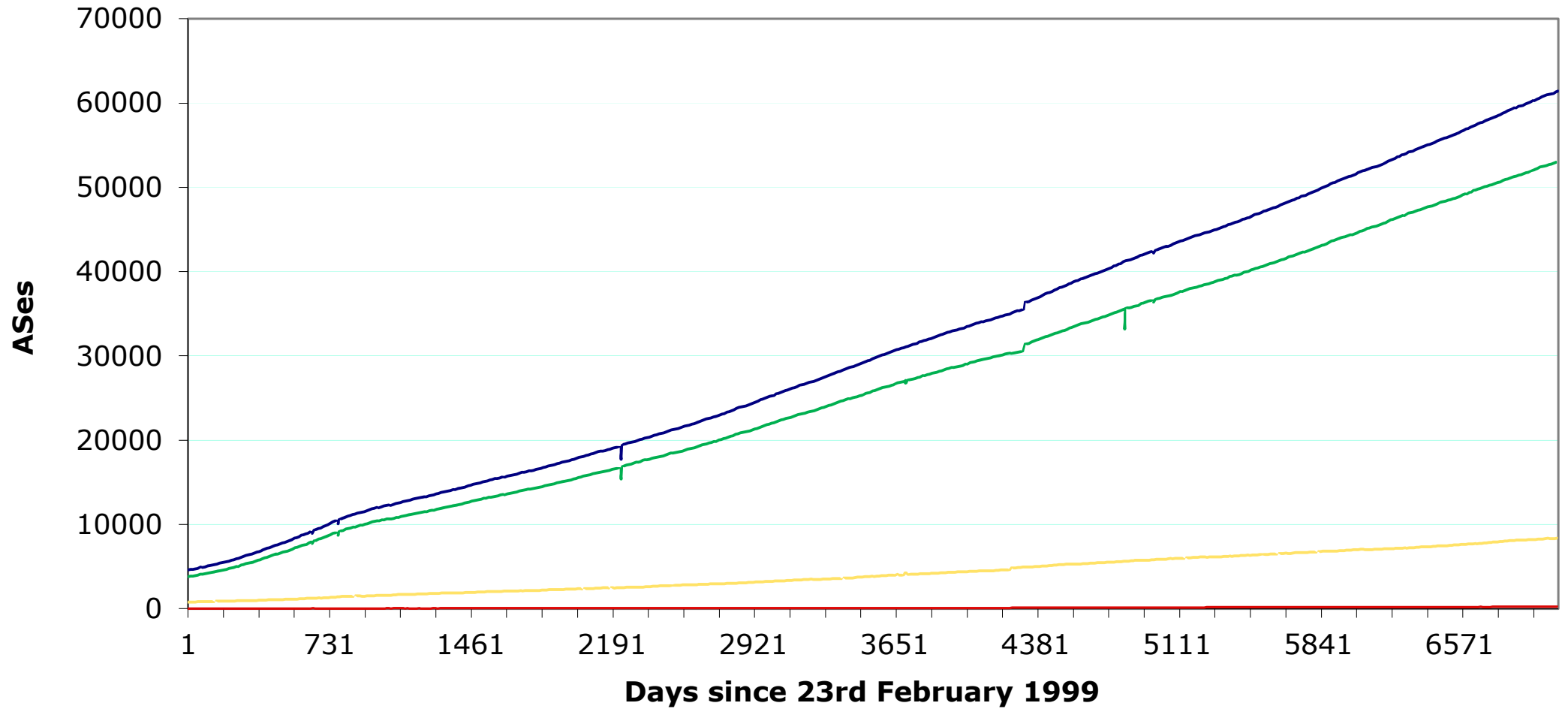
/24s announced



Address Space announced



AS Announcements



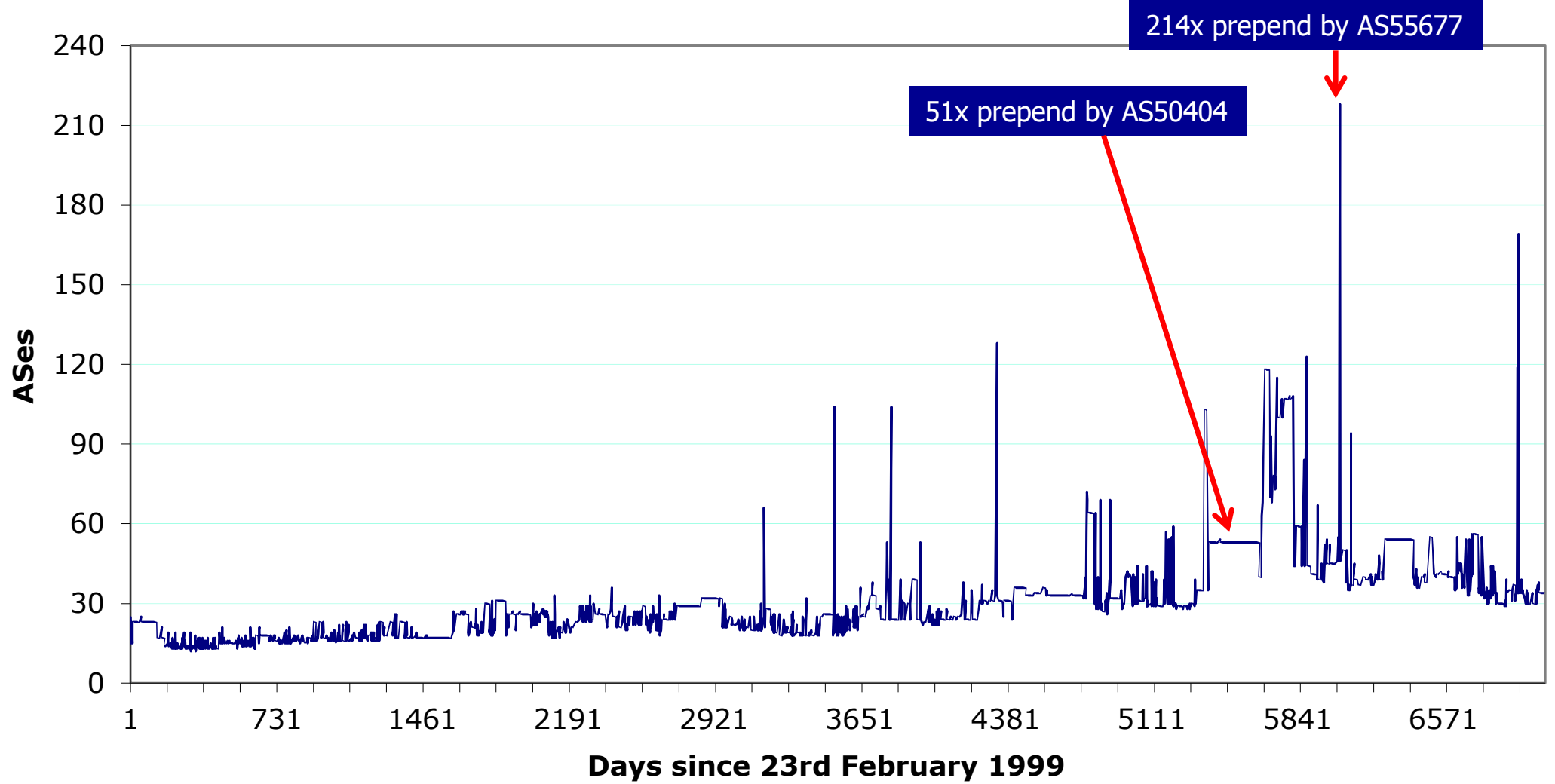
— Total ASNs

— Origin-only ASNs

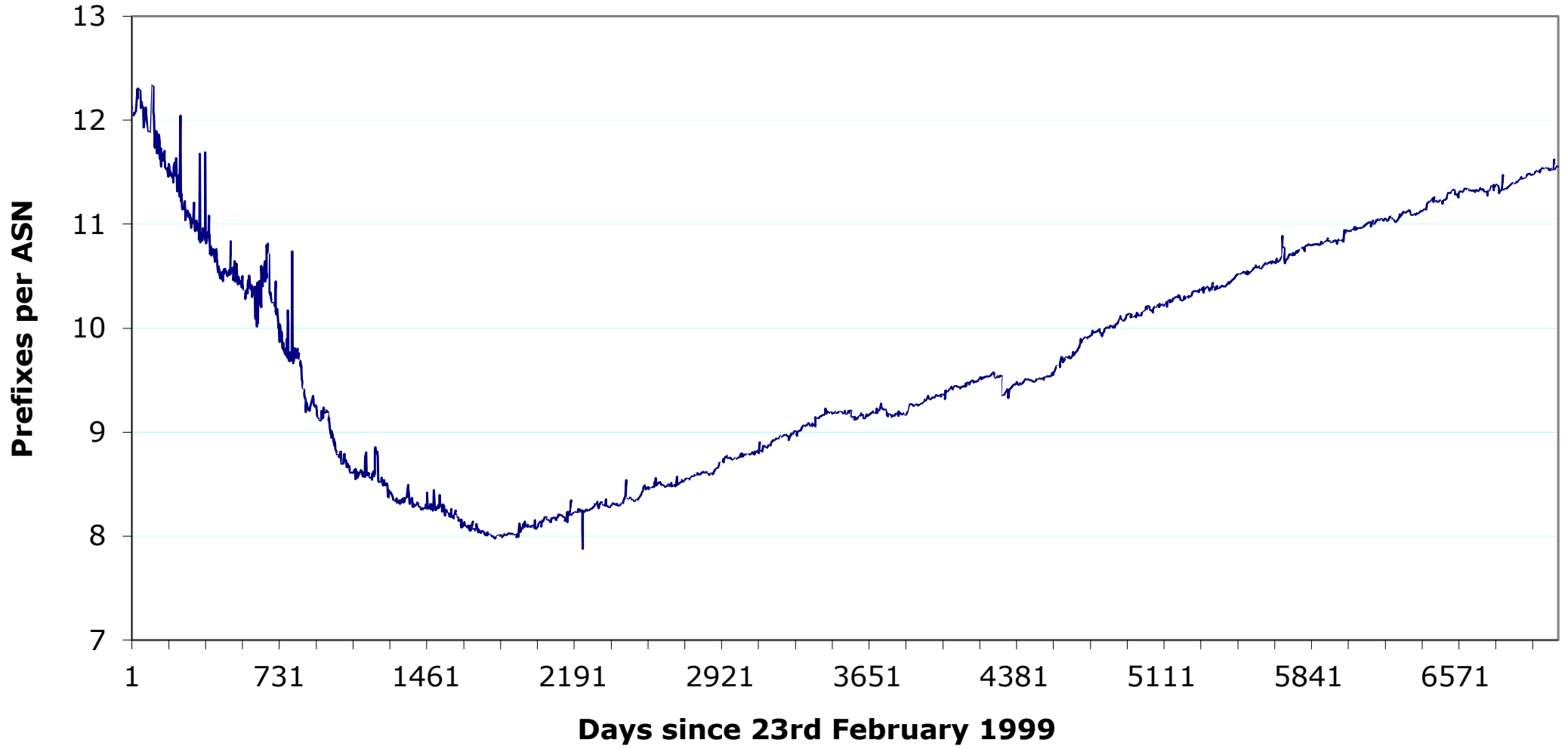
— ASN providing Transit & Origin

— Transit-only ASNs

Maximum AS Path Length



Prefixes per ASN





Looking at Deaggregation

- CIDR Report
 - www.cidr-report.org
 - Encourages aggregation following CIDRisation of Internet
 - Today: extensive suite of reports and tools covering state of BGP table
- Routing Report
 - BGP table status on per RIR basis
 - Original CIDR Report and a whole lot more



Deaggregation Factor

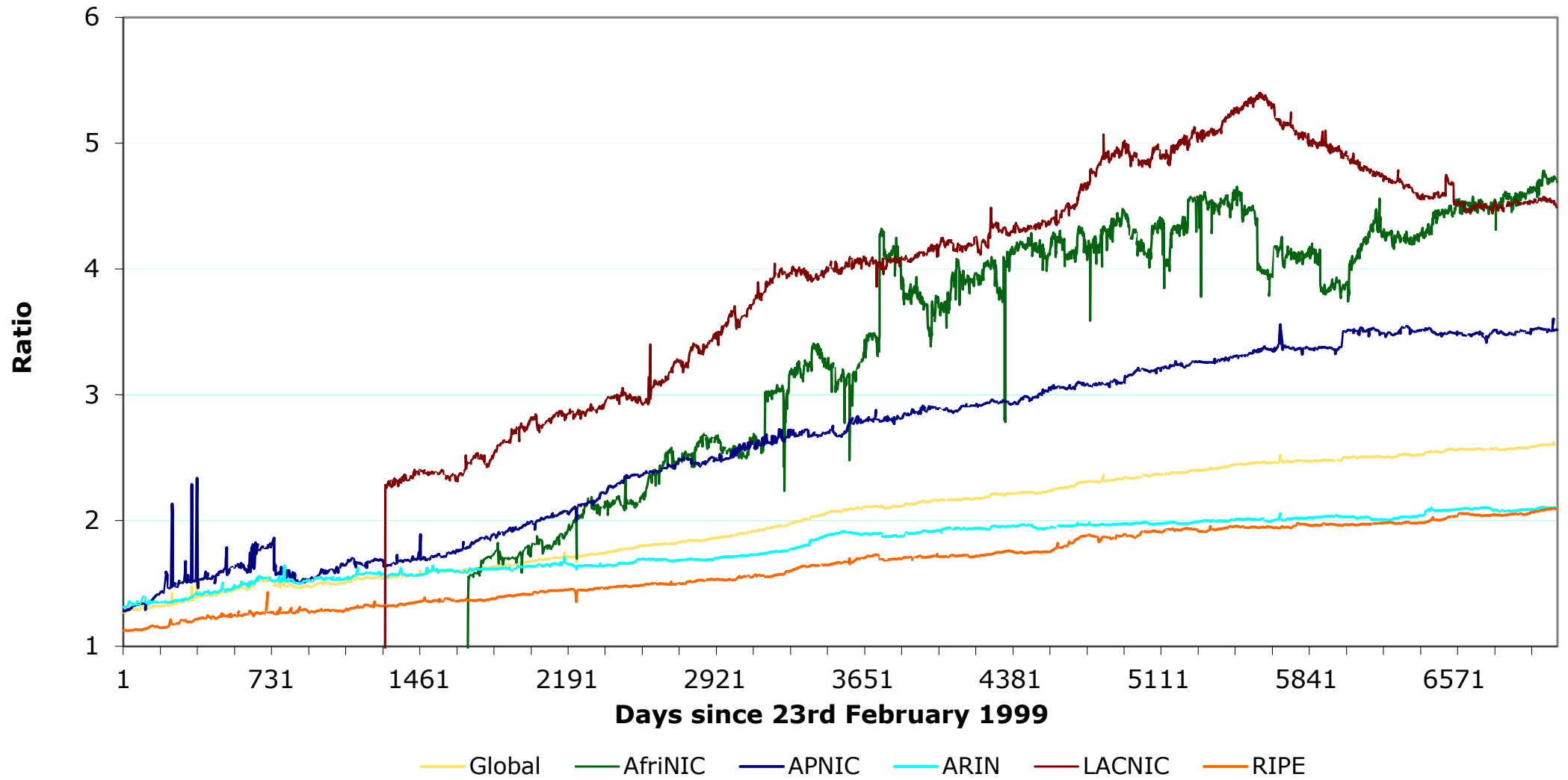
- Routing Report
 - One summary takes BGP table and aggregates prefixes by origin AS
 - Called “Max Aggregation” in report
 - Global and per RIR basis
 - <http://thyme.apnic.net/current/>
- Calculates **Deaggregation** Factor:
 - Measure of Routing Table size/Aggregated Size
 - Global value has been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



August 2018

- **Total Prefixes**
- Global BGP Table
 - 710k prefixes
- North America
 - 211k prefixes
- Europe & Middle East
 - 194k prefixes
- Asia & Pacific
 - 194k prefixes
- Latin America & Caribbean
 - 92k prefixes
- Africa
 - 19k prefixes
- **Deaggregation Factor**
- Global Average
 - 2.60
- North America
 - 2.10
- Europe & Middle East
 - 2.09
- Asia & Pacific
 - 3.51
- Latin America & Caribbean
 - 4.50
- Africa
 - 4.69

Deaggregation: RIR Regions vs Global



Asia Pacific Aggregation Savings Summary

ASN	No of Nets	Savings	Description
4538	4689	4615	ERX-CERNET-BKB China Education and Research Net
7545	4397	3929	TPG-INTERNET-AP TPG Telecom Limited, AU
7552	2978	2895	VIETEL-AS-AP Viettel Group, VN
9394	2537	2506	CTTNET China TieTong Telecommunications Corpora
45899	2579	2423	VNPT-AS-VN VNPT Corp, VN
9829	2813	2270	BSNL-NIB National Internet Backbone, IN
9808	2240	2214	CMNET-GD Guangdong Mobile Communication Co.Ltd.
17974	2262	2190	TELKOMNET-AS2-AP PT Telekomunikasi Indonesia, I
4766	2845	2078	KIXS-AS-KR Korea Telecom, KR
4755	2115	1909	TATACOMM-AS TATA Communications formerly VSNL i
23969	1763	1747	TOT-NET TOT Public Company Limited, TH
9498	1878	1727	BBIL-AP BHARTI Airtel Ltd., IN
45609	1763	1551	BHARTI-MOBILITY-AS-AP Bharti Airtel Ltd. AS for
45090	1384	1342	CNNIC-TENCENT-NET-AP Shenzhen Tencent Computer
18403	1332	1304	FPT-AS-AP The Corporation for Financing & Promo
55430	1224	1197	STARHUBINTERNET-AS-NGNBN Starhub Internet Pte L
4808	1611	1161	CHINA169-BJ China Unicom Beijing Province Netwo
9583	1631	1072	SIFY-AS-IN Sify Limited, IN
56040	1119	1067	CMNET-GUANGDONG-AP China Mobile communications
24560	1314	1001	AIRTELBROADBAND-AS-AP Bharti Airtel Ltd., Telem
18101	959	827	RELIANCE-COMMUNICATIONS-IN Reliance Communicati
17638	809	787	CHINATELECOM-TJ-AS-AP ASN for TIANJIN Provincia
45528	973	784	TIKONAIN-AS Tikona Infinet Ltd., IN
17488	964	750	HATHWAY-NET-AP Hathway IP Over Cable Internet,

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

Bangladesh Aggregation Savings Summary

ASN	No of Nets	Savings	Description
45904	198	189	BANGLALION-WIMAX-BD Banglalion Communications L
23956	127	122	AMBERIT-BD-AS AmberIT Limited, BD
45951	123	115	AUGERE-AS-AP Augere Wireless Broadband Banglade
24342	124	102	BRAC-BDMAIL-AS-BD BRAC BDMail Network Ltd., BD
17469	74	70	ACCESSTEL-AS-AP Access Telecom (BD) Ltd., BD
23923	72	68	AGNI-AS Agni Systems Limited, BD
56115	67	65	NGGL-BD New Generation Graphics Limited, BD
24323	76	65	AAMRA-NETWORKS-AS-AP aamra networks limited, BD
17471	69	64	CYBERNET-BD-AS Grameen Cybernet Ltd. Bangladesh
38712	58	56	TELNET-AS-BD-AP Telnet Communication Limited, B
7565	60	52	BDCOM-BD Rang's Nilu Square, 5th Floor, House 75
17806	49	47	MANGOTELESERVICE-AS-BD Tire-1 IP Transit Provid
9230	49	46	BOL-BD-AP Bangladesh Online Ltd., BD
24389	48	42	GRAMEENPHONE-AS-AP GrameenPhone Ltd., BD
24122	45	41	BDCOM-BD-AS-AP BDCOM Online Limited, BD
23893	42	41	BPL-BD Bangla Phone Ltd, BD
45588	50	40	BTCL-ISP-AS Bangladesh Telecommunications Compa
9832	44	39	ISN-AS-AP ISN, Internet Service Provider, BD
38031	44	39	OPTIMAX-BD-AS-AP OptiMax Communication Ltd., BD
38203	39	33	ADNTELECOMLTD-BD ADN Telecom Ltd., BD
38067	46	33	RADIANT Radiant Communications Limited, BD
63969	49	32	RACEONLINE-BD Race Online Limited, BD
45326	42	32	BBTS-AS-AP Broad Band Telecom Services Ltd, BD
38592	37	31	CTGONLINE-AS-AP Chittagong Online Limited AS385
58691	40	29	DELTA-BD Delta, BD
134180	36	27	BRISKSYSTEMS-AS-AP Md. Shariful Islam T/A BRISK



Importance of Aggregation

- Size of routing table
 - Router memory no longer seems to be a problem
 - Routers routinely carry over 1 million prefixes
- Convergence of the Routing System
 - Is this something we need to worry about?
 - Bigger table takes longer for CPU to process
 - BGP updates take longer to deal with
 - BGP Instability Report tracks routing system update activity
 - <http://bgpupdates.potaroo.net/instability/bgpupd.html>

The BGP Instability Report

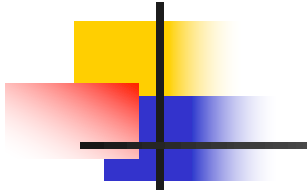
The BGP Instability Report is updated daily. This report was generated on 08 August 2018 06:25 (UTC+1000)

50 Most active ASes for the past 7 days

RANK	ASN	UPDs	%	Prefixes	UPDs/Prefix	AS NAME
1	9829	80164	2.54%	2813	28.50	BSNL-NIB National Internet Backbone, IN
2	135577	79508	2.52%	8	9938.50	SAP_DC_SHA SAP, SG
3	8048	71690	2.27%	401	178.78	CANTV Servicios, Venezuela, VE
4	50010	56975	1.80%	203	280.67	NAWRAS-AS Sultanate of Oman, OM
5	17974	37653	1.19%	2264	16.63	TELKOMNET-AS2-AP PT Telekomunikasi Indonesia, ID
6	13118	36695	1.16%	49	748.88	ASN-YARTELECOM PJSC Rostelecom, RU
7	51828	31493	1.00%	349	90.24	PJSCFARSTELECOMMUNICATIONCOMPANY, IR
8	18809	29800	0.94%	389	76.61	Cable Onda, PA
9	11830	25508	0.81%	2658	9.60	Instituto Costarricense de Electricidad y Telecom., CR
10	9503	22027	0.70%	56	393.34	FX-PRIMARY-AS FX Networks Limited, NZ
11	50710	19241	0.61%	518	37.14	EARTHLINK-AS, IQ
12	14600	19044	0.60%	9	2116.00	MXL-PROD - MX Logic, Inc., US
13	23969	18839	0.60%	1767	10.66	TOT-NET TOT Public Company Limited, TH
14	24550	18762	0.59%	66	284.27	WEBSURFERNP-AS-NP Websurfer Nepal Internet Service Provider, NP
15	45899	17482	0.55%	2722	6.42	VNPT-AS-VN VNPT Corp, VN
16	7713	17431	0.55%	959	18.18	TELKOMNET-AS-AP PT Telekomunikasi Indonesia, ID
17	11139	16304	0.52%	453	35.99	CWC-ROC-11139 - Cable & Wireless Dominica, DM
18	45271	15528	0.49%	679	22.87	ICLNET-AS-AP Idea Cellular Limited, IN
19	37148	14740	0.47%	74	199.19	globacom-as, NG
20	3561	13896	0.44%	480	28.95	CENTURYLINK-LEGACY-SAVVIS - Savvis, US
21	5972	13766	0.44%	1371	10.04	DNIC-ASBLK-05800-06055 - DoD Network Information Center, US
22	29256	13648	0.43%	265	51.50	INT-PDN-STE-AS STE PDN Internal AS, SY
23	43754	13596	0.43%	278	48.91	ASIATECH, IR
24	2561	12869	0.41%	79	162.90	EUN, EG
25	8452	12725	0.40%	659	19.31	TE-AS TE-AS, EG
26	58224	12169	0.39%	480	25.35	TCI, IR
27	31549	12039	0.38%	240	50.16	RASANA, IR
28	8151	11862	0.38%	5192	2.28	Uninet S.A. de C.V., MX
29	45090	11610	0.37%	1559	7.45	CNNIC-TENCENT-NET-AP Shenzhen Tencent Computer Systems Company Limited, CN
30	3832	11462	0.36%	20	573.10	CINE-NET - Cinenet Communications, US
31	36903	11460	0.36%	778	14.73	MT-MPLS, MA
32	196742	11256	0.36%	24	469.00	EKRAN-AS, RU
33	5087	11177	0.35%	69	161.99	LANKA-COM Lanka Communication Services, LK

50 Most active Prefixes for the past 7 days

RANK	PREFIX	UPDs	%	Origin AS -- AS NAME
1	200.90.138.0/24	23189	0.69%	18809 -- Cable Onda, PA
2	157.133.212.0/24	19888	0.59%	135577 -- SAP_DC_SHA SAP, SG
3	157.133.186.0/23	19879	0.59%	135577 -- SAP_DC_SHA SAP, SG
4	157.133.192.0/22	19872	0.59%	135577 -- SAP_DC_SHA SAP, SG
5	157.133.236.0/24	19869	0.59%	135577 -- SAP_DC_SHA SAP, SG
6	208.65.144.0/24	19036	0.57%	14600 -- MXL-PROD - MX Logic, Inc., US
7	93.181.224.0/20	18362	0.55%	13118 -- ASN-YARTELECOM PJSC Rostelecom, RU
8	93.181.192.0/19	18333	0.55%	13118 -- ASN-YARTELECOM PJSC Rostelecom, RU
9	64.70.30.0/24	12996	0.39%	3561 -- CENTURYLINK-LEGACY-SAVVIS - Savvis, US
10	103.198.184.0/24	11187	0.33%	9503 -- FX-PRIMARY-AS FX Networks Limited, NZ
11	103.198.185.0/24	10840	0.32%	9503 -- FX-PRIMARY-AS FX Networks Limited, NZ
12	116.12.123.0/24	10487	0.31%	5087 -- LANKA-COM Lanka Communication Services, LK
13	128.0.164.0/22	10362	0.31%	196742 -- EKLAN-AS, RU
14	120.50.4.0/23	9568	0.29%	38712 -- TELNET-AS-BD-AP Telnet Communication Limited, BD
15	209.59.121.0/24	9378	0.28%	11139 -- CWC-ROC-11139 - Cable & Wireless Dominica, DM
16	95.140.160.0/24	8492	0.25%	12524 -- , JO
17	203.34.2.0/24	8220	0.25%	4739 -- INTERNODE-AS Internode Pty Ltd, AU
18	198.148.151.0/24	7831	0.23%	3832 -- CINE-NET - Cinenet Communications, US
19	76.72.84.0/24	7410	0.22%	25921 -- LUS-FIBER-LCG - Lafayette Consolidated Government, US
20	68.69.37.0/24	7406	0.22%	14858 -- HISNET - Hanson Information Systems, Inc. / Family Net, US 19058 -- IRTC-NET - Illinois Rural Telecommunication Co., US
21	195.13.50.0/24	6445	0.19%	58319 -- KAZAKOV-AS, RU
22	104.237.191.0/24	6193	0.19%	36040 -- YOUTUBE - Google LLC, US
23	68.69.45.0/24	6019	0.18%	14858 -- HISNET - Hanson Information Systems, Inc. / Family Net, US 19058 -- IRTC-NET - Illinois Rural Telecommunication Co., US
24	198.228.186.0/24	5528	0.17%	852 -- ASN852 - TELUS Communications Inc., CA
25	209.177.171.0/24	5106	0.15%	18465 -- WORKDAY-01 - Workday, Inc., US
26	185.59.252.0/22	5013	0.15%	201897 -- RBPASN, LV
27	83.131.0.0/22	4980	0.15%	1902 -- PAN-NET Deutsche Telekom Pan-Net s.r.o., SK
28	196.46.242.0/24	4912	0.15%	36873 -- VNL1-AS, NG
29	41.181.164.0/24	4571	0.14%	16637 -- MTNNS-AS, ZA
30	41.181.174.0/24	4559	0.14%	16637 -- MTNNS-AS, ZA
31	181.191.26.0/24	4356	0.13%	263739 -- NODONET S.A., AR
32	194.8.31.0/24	3977	0.12%	29468 -- INFRACOM, SE
33	199.245.187.0/24	3631	0.11%	3832 -- CINE-NET - Cinenet Communications, US
34	216.238.254.0/23	3440	0.10%	13904 -- COSLINK - Cherryland Services Inc, US
35	167.64.96.0/22	3421	0.10%	12052 -- VFC - VF Services, Inc. Information Technology Services, US
36	147.104.36.0/24	3301	0.10%	1501 -- DNIC-ASBLK-01500-01502 - Headquarters, USAISC, US





Observations

- IPv4 Routing table continues to grow
 - Linear growth for last 7 years
 - Even though total address space announced has levelled off over the last 2 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

Internet IPv4 Routing Table Analysis Update



Questions?