

Internet IPv4 Routing Table Analysis Update



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SANOG 29

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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 22 January 2017

BGP routing table entries examined:	629252
Prefixes after maximum aggregation (per Origin AS):	221865
Deaggregation factor:	2.84
Unique aggregates announced (without unneeded subnets):	305015
Total ASes present in the Internet Routing Table:	55641
Prefixes per ASN:	11.31
Origin-only ASes present in the Internet Routing Table:	36237
Origin ASes announcing only one prefix:	15199
Transit ASes present in the Internet Routing Table:	6552
Transit-only ASes present in the Internet Routing Table:	176
Average AS path length visible in the Internet Routing Table:	4.3
Max AS path length visible:	55
Max AS path prepend of ASN (55644)	51
Prefixes from unregistered ASNs in the Routing Table:	50
Unregistered ASNs in the Routing Table:	15
Number of 32-bit ASNs allocated by the RIRs:	17005
Number of 32-bit ASNs visible in the Routing Table:	12852
Prefixes from 32-bit ASNs in the Routing Table:	53046
Number of bogon 32-bit ASNs visible in the Routing Table:	860
Special use prefixes present in the Routing Table:	0
Prefixes being announced from unallocated address space:	384
Number of addresses announced to Internet:	2833597188
Equivalent to 168 /8s, 229 /16s and 67 /24s	
Percentage of available address space announced:	76.5
Percentage of allocated address space announced:	76.5
Percentage of available address space allocated:	100.0
Percentage of address space in use by end-sites:	98.4
Total number of prefixes smaller than registry allocations:	208432

APNIC Region

Prefixes being announced by APNIC Region ASes:	156672
Total APNIC prefixes after maximum aggregation:	43131
APNIC Deaggregation factor:	3.63
Prefixes being announced from the APNIC address blocks:	171473
Unique aggregates announced from the APNIC address blocks:	71020
APNIC Region origin ASes present in the Internet Routing Table:	5192
APNIC Prefixes per ASN:	33.03
APNIC Region origin ASes announcing only one prefix:	1144
APNIC Region transit ASes present in the Internet Routing Table:	939
Average APNIC Region AS path length visible:	4.5
Max APNIC Region AS path length visible:	55
Number of APNIC region 32-bit ASNs visible in the Routing Table:	2628
Number of APNIC addresses announced to Internet:	762126244
Equivalent to 45 /8s, 109 /16s and 31 /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
4538	5540	4190	74	ERX-CERNET-BKB China Education and
7545	3736	391	256	TPG-INTERNET-AP TPG Telecom Limite
22773	3617	2968	151	ASN-CXA-ALL-CCI-22773-RDC - Cox Co
10620	3538	545	156	Telmex Colombia S.A., CO
6327	3299	1333	83	SHAW - Shaw Communications Inc.,
39891	3141	163	17	ALJAWWALSTC-AS , SA
20940	3014	1138	2135	AKAMAI-ASN1 , US
17974	2978	905	71	TELKOMNET-AS2-AP PT Telekomunikasi
4766	2732	11133	743	KIXS-AS-KR Korea Telecom, KR
9829	2694	1499	537	BSNL-NIB National Internet Backbon
8151	2487	3380	552	Uninet S.A. de C.V., MX
9808	2277	8698	33	CMNET-GD Guangdong Mobile Communic
9121	2206	1707	95	TTNET , TR
18566	2192	405	109	MEGAPATH5-US - MegaPath Corporatio
6389	2094	3671	39	BELLSOUTH-NET-BLK - BellSouth.net
4755	2053	429	219	TATACOMM-AS TATA Communications
34984	1987	327	376	TELLCOM-AS , TR
20115	1960	2027	404	CHARTER-NET-HKY-NC - Charter Commu
45899	1811	1272	96	VNPT-AS-VN VNPT Corp, VN
11830	1800	368	66	Instituto Costarricense de Electri

AfriNIC APNIC ARIN LACNIC RIPE NCC

Number of prefixes announced by prefix length

/1:0	/2:0	/3:0	/4:0	/5:0	/6:0
/7:0	/8:16	/9:13	/10:36	/11:103	/12:276
/13:532	/14:1049	/15:1794	/16:13185	/17:7785	/18:13043
/19:25161	/20:38129	/21:40747	/22:73522	/23:61513	/24:350991
/25:553	/26:409	/27:294	/28:34	/29:20	/30:18
/31:1	/32:28				

January 2017 ↑

January 2016 ↓

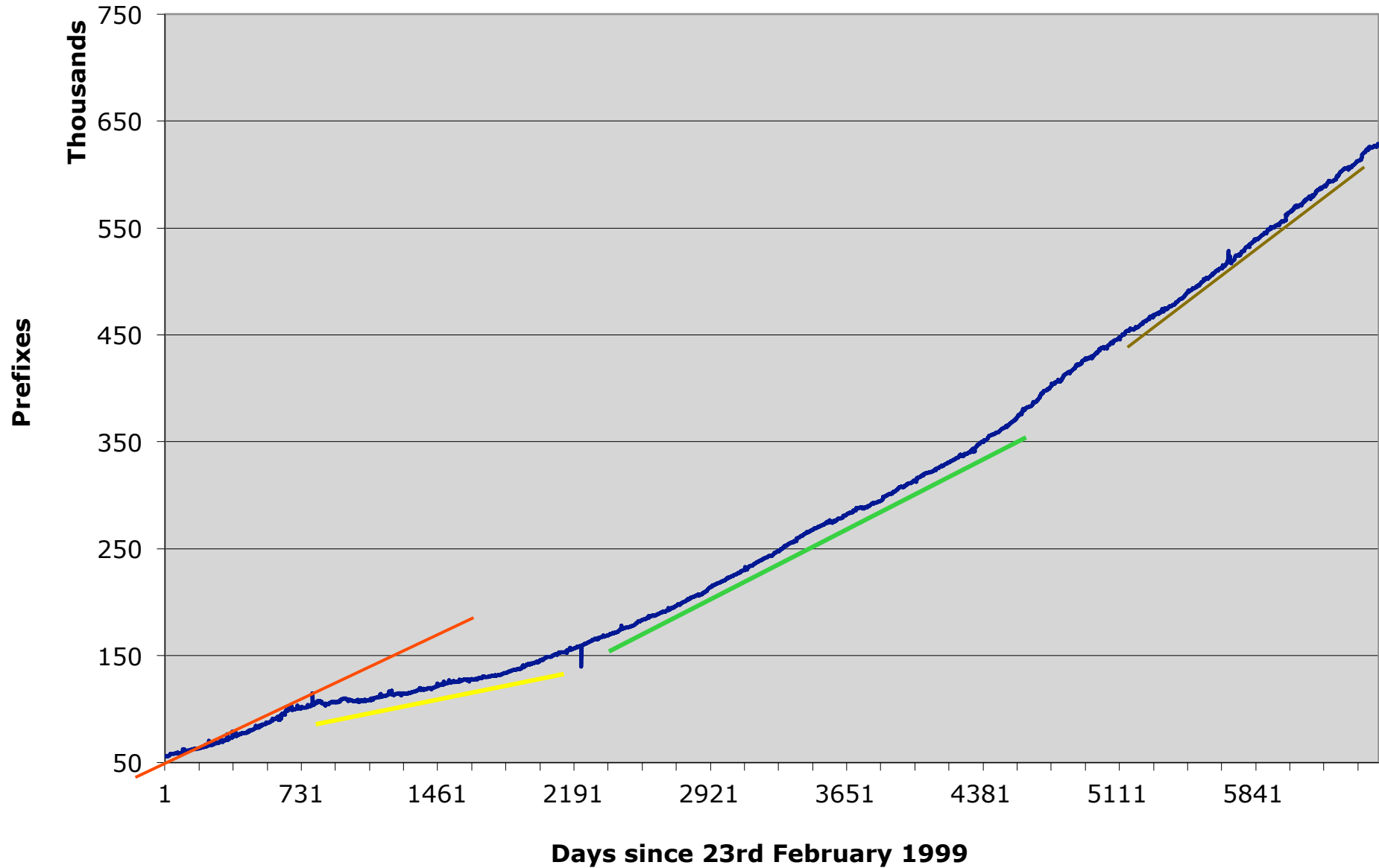
Number of prefixes announced by prefix length

/1:0	/2:0	/3:0	/4:0	/5:0	/6:0
/7:0	/8:16	/9:13	/10:36	/11:101	/12:265
/13:507	/14:1015	/15:1750	/16:12972	/17:7441	/18:12622
/19:25575	/20:38003	/21:40091	/22:64045	/23:55549	/24:317853
/25:543	/26:570	/27:388	/28:17	/29:16	/30:9
/31:0	/32:21				

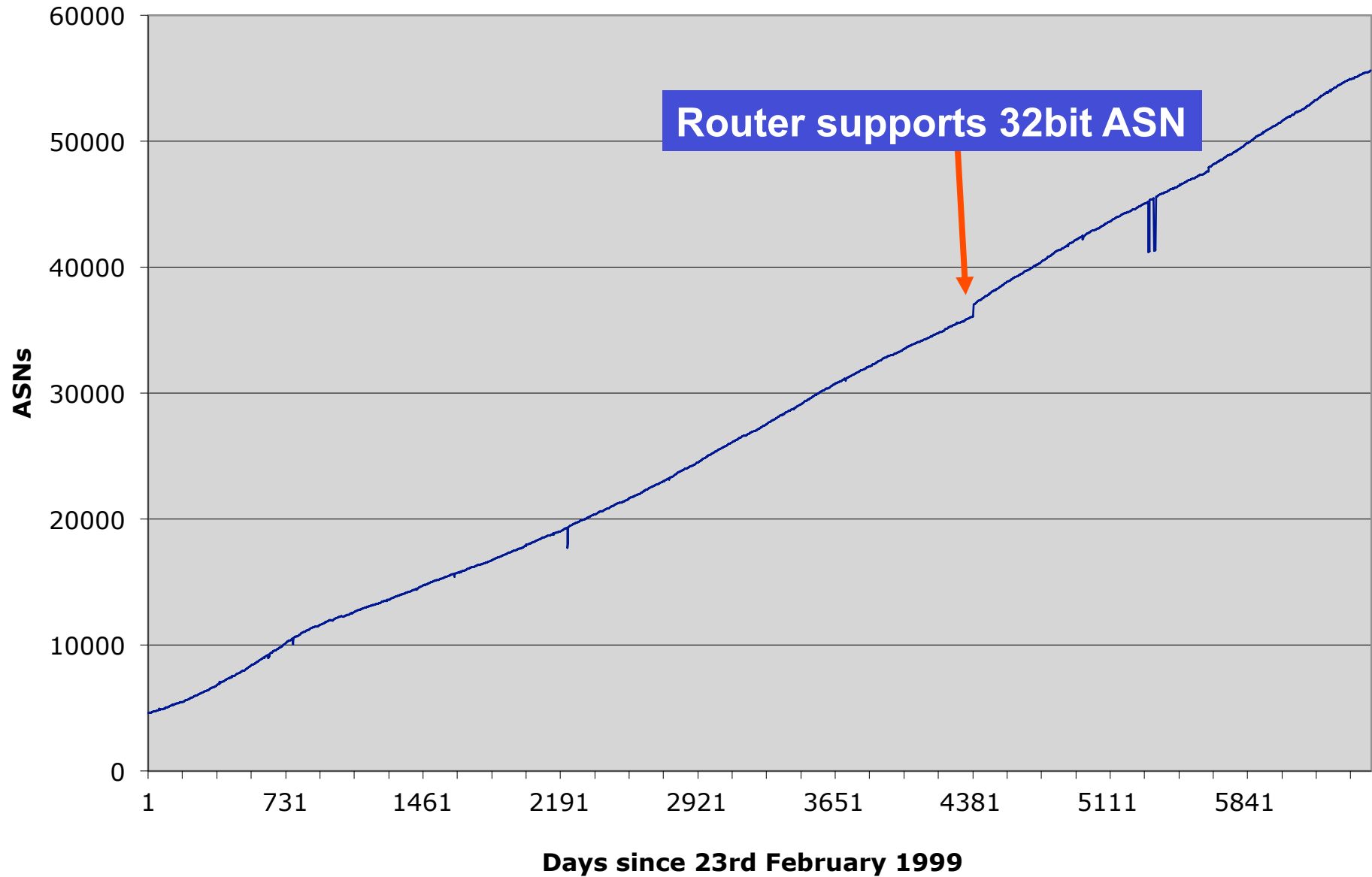
Prefixes Smaller than Registry Allocations

ASN	No of nets	Total ann.	Description
6327	3095	3299	SHAW - Shaw Communications Inc., CA
22773	2814	3617	ASN-CXA-ALL-CCI-22773-RDC - Cox Communi
39891	2704	3141	ALJAWWALSTC-AS , SA
18566	2085	2192	MEGAPATH5-US - MegaPath Corporation, US
9121	1548	2206	TTNET , TR
30036	1511	1697	MEDIACOM-ENTERPRISE-BUSINESS - Mediacom
10620	1449	3538	Telmex Colombia S.A., CO
6389	1392	2094	BELLSOUTH-NET-BLK - BellSouth.net Inc.,
13188	1349	1599	TRIOLAN , UA
6983	1322	1678	ITCDELTA - Earthlink, Inc., US
34984	1274	1987	TELLCOM-AS , TR
11492	1239	1342	CABLEONE - CABLE ONE, INC., US
11830	1227	1800	Instituto Costarricense de Electricidad
6849	1096	1271	UKRTELNET , UA
6147	934	1352	Telefonica del Peru S.A.A., PE
209	878	1741	CENTURYLINK-US-LEGACY-QWEST - Qwest Com
20940	865	3014	AKAMAI-ASN1 , US
6503	849	1547	Axtel, S.A.B. de C.V., MX
13977	832	866	CTELCO - FAIRPOINT COMMUNICATIONS, INC.
7155	824	949	VIASAT-SP-BACKBONE - ViaSat,Inc., US

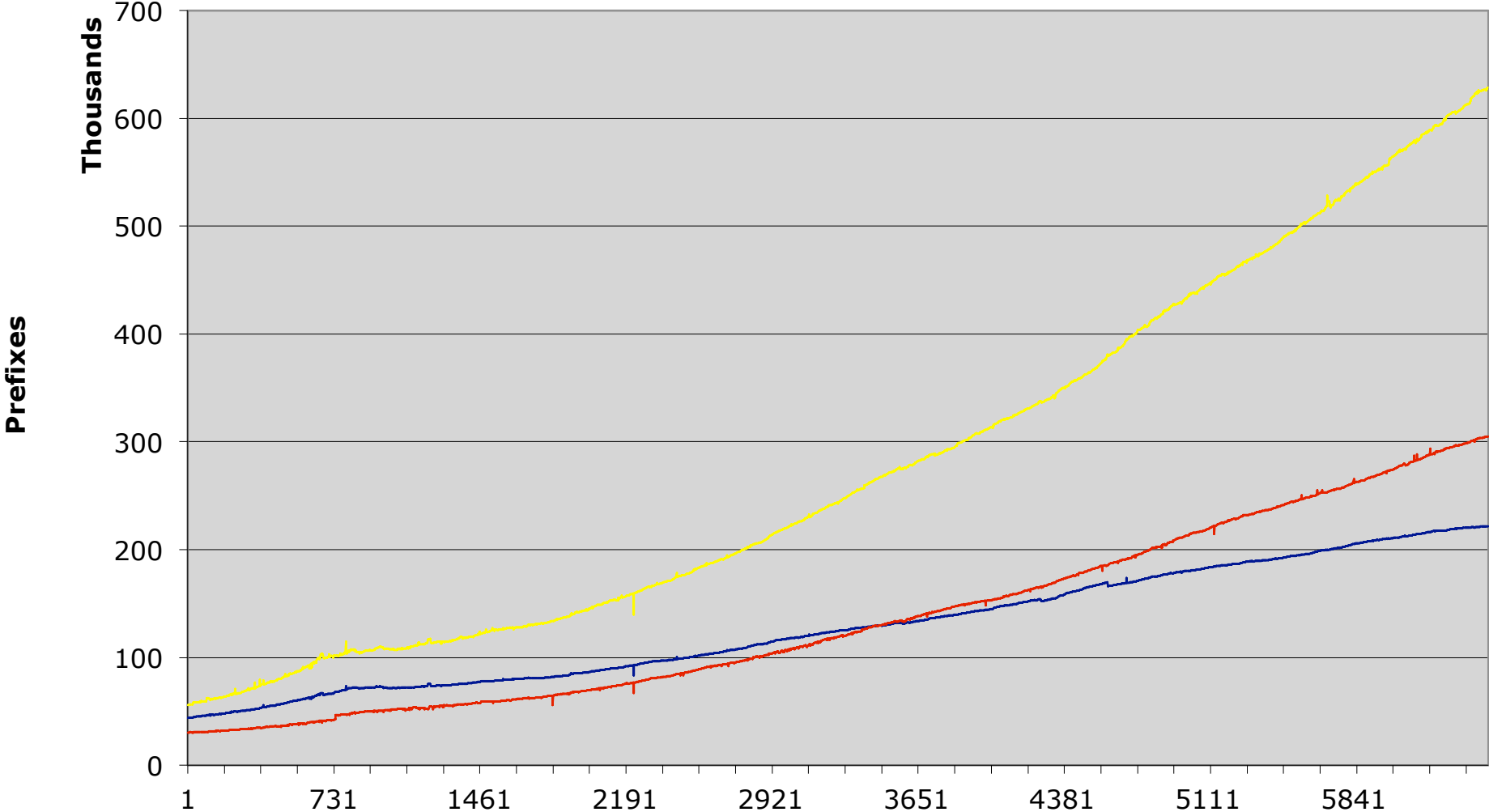
BGP Routing Table



AS Growth

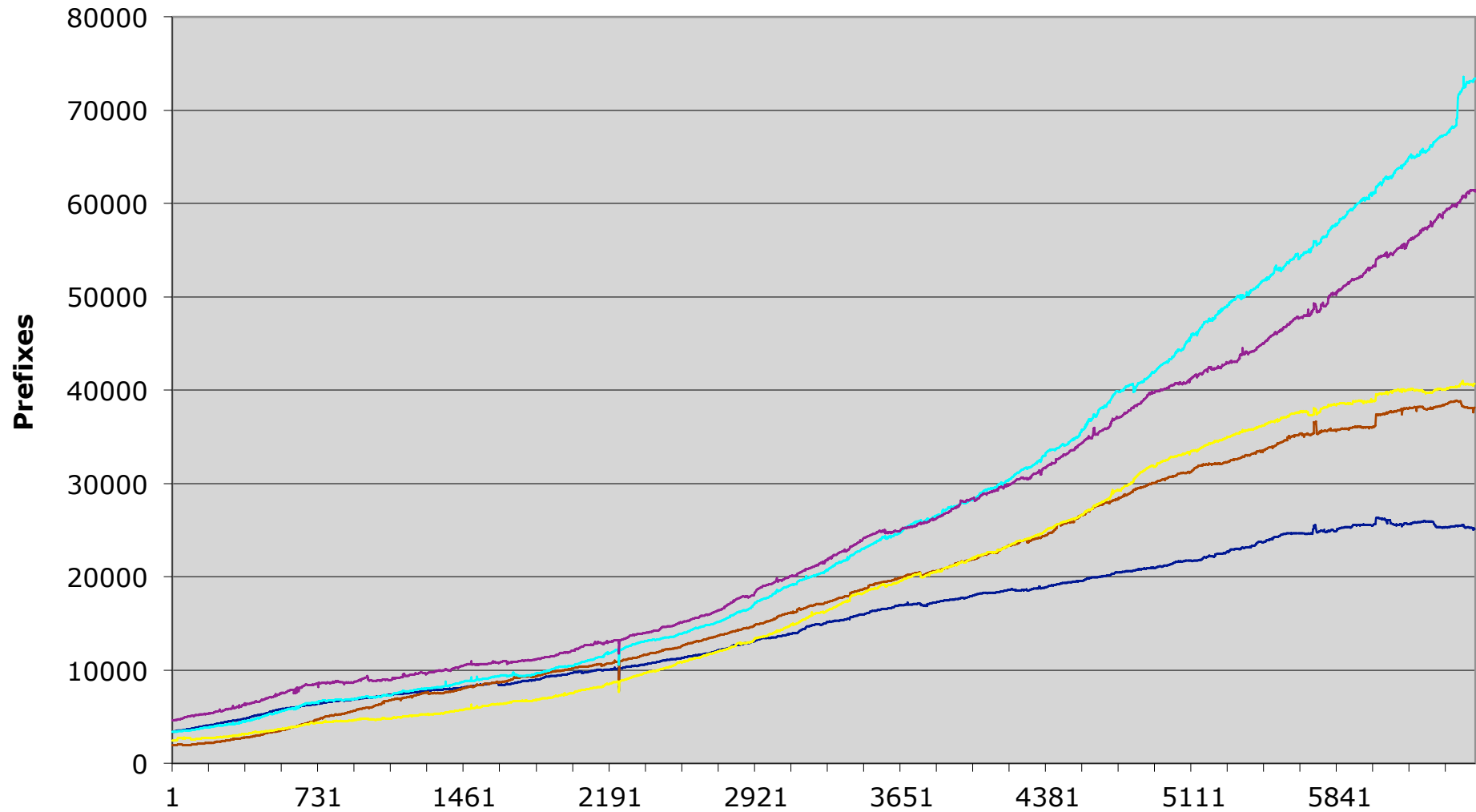


Max Aggregation vs Unique Prefixes



— Max Aggregation — Unique Prefixes — Global BGP Table

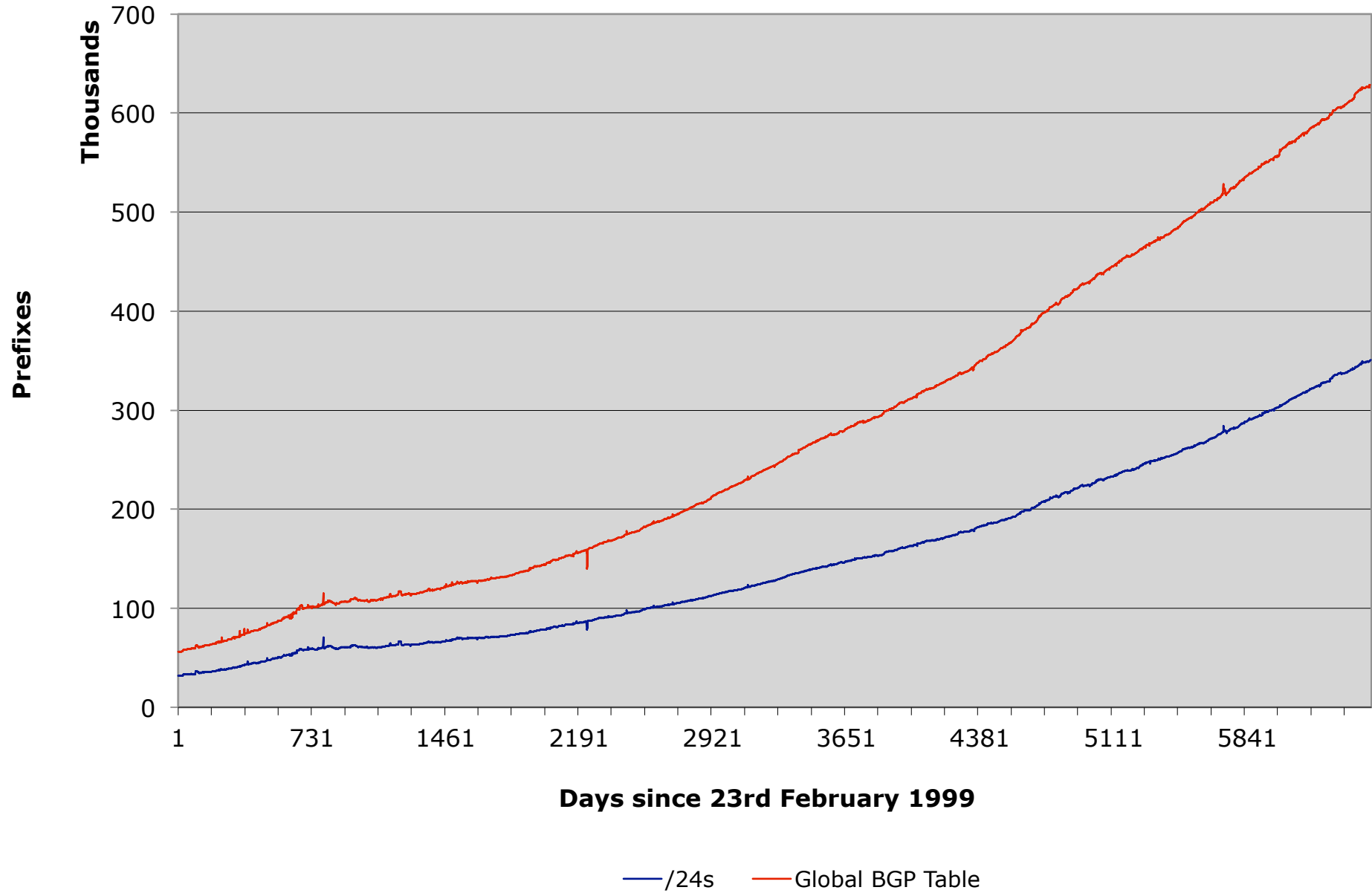
Prefix sizes announced



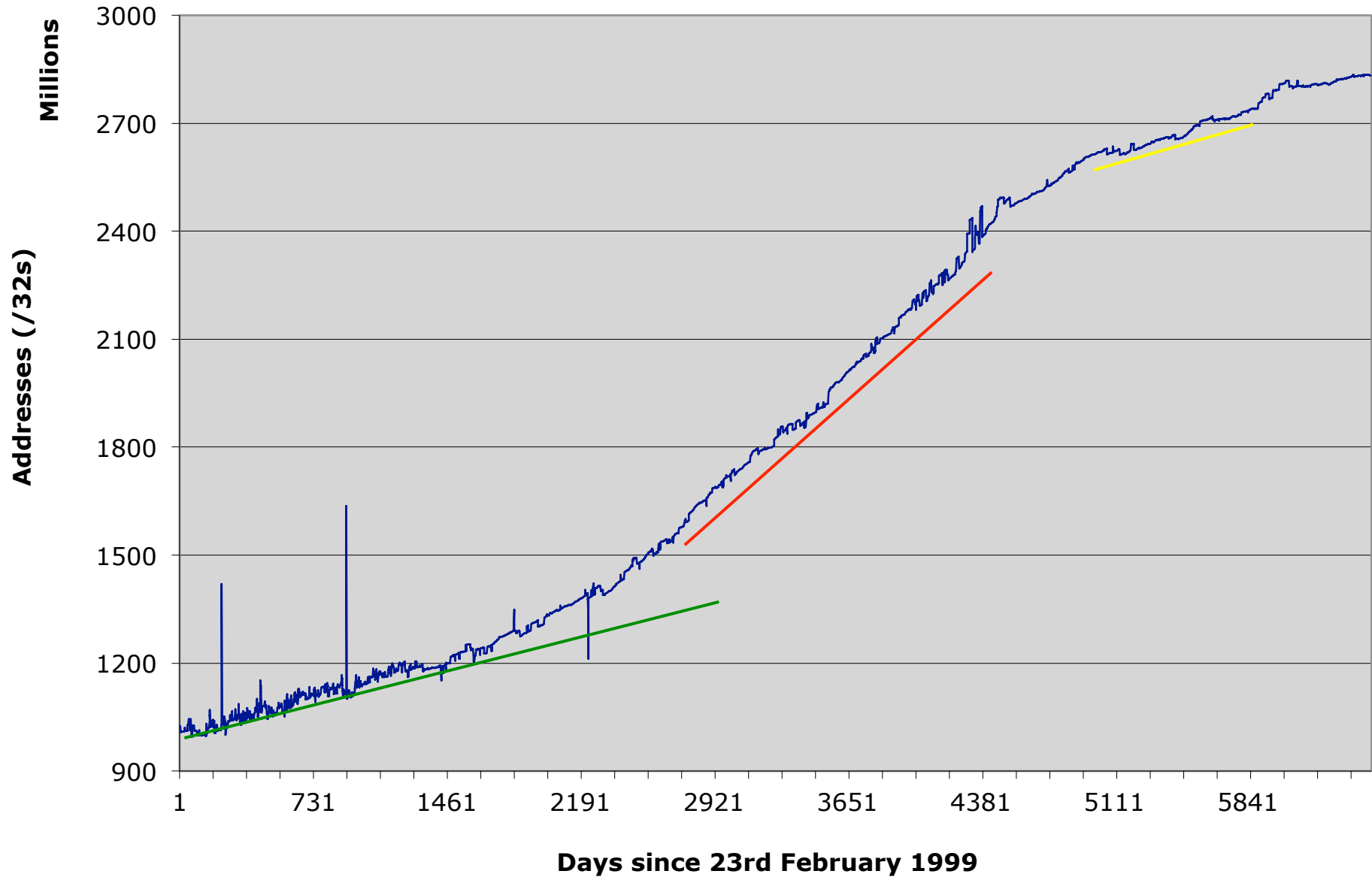
Days since 23rd February 1999

— /19 — /20 — /21 — /22 — /23

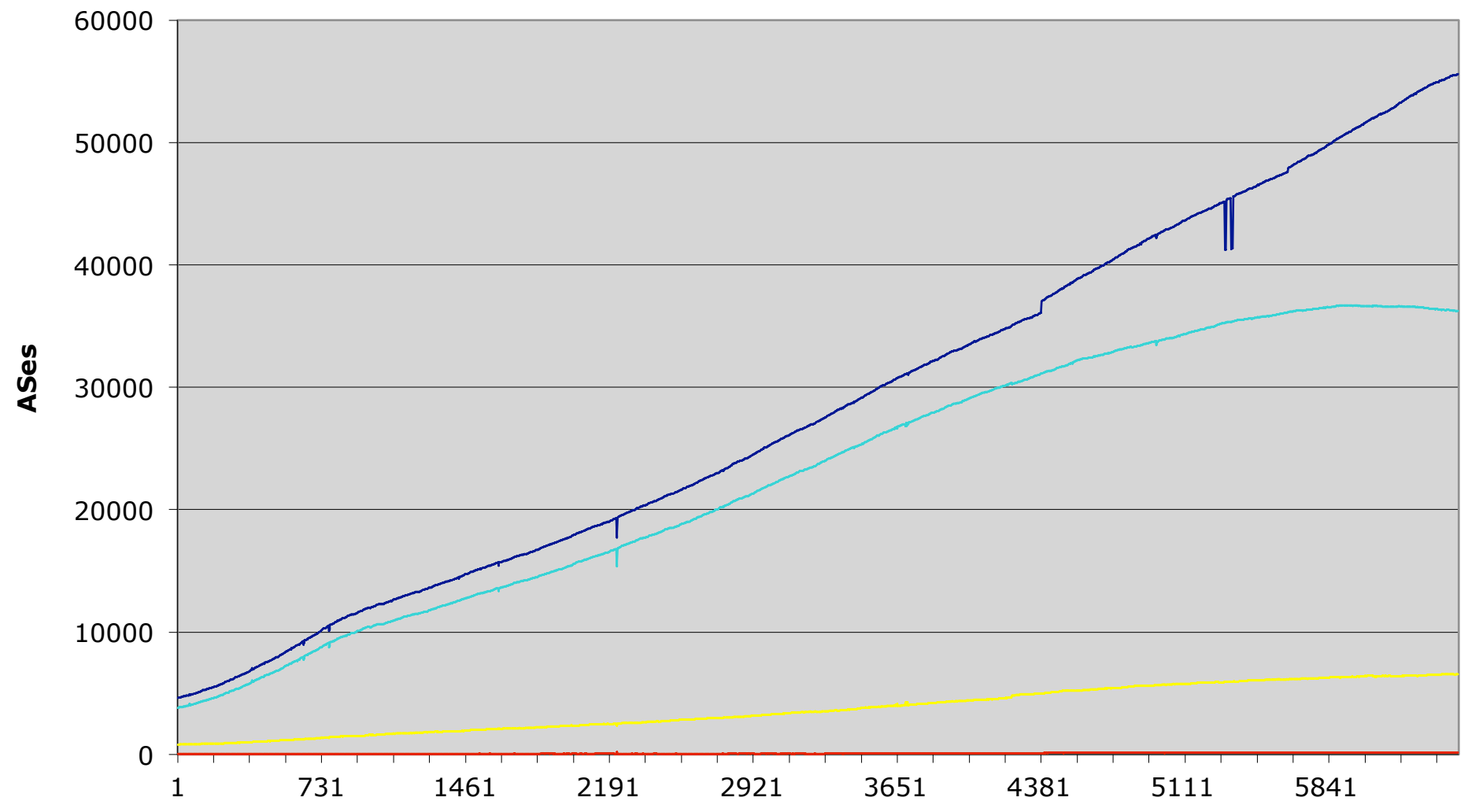
/24s announced



Address Space announced

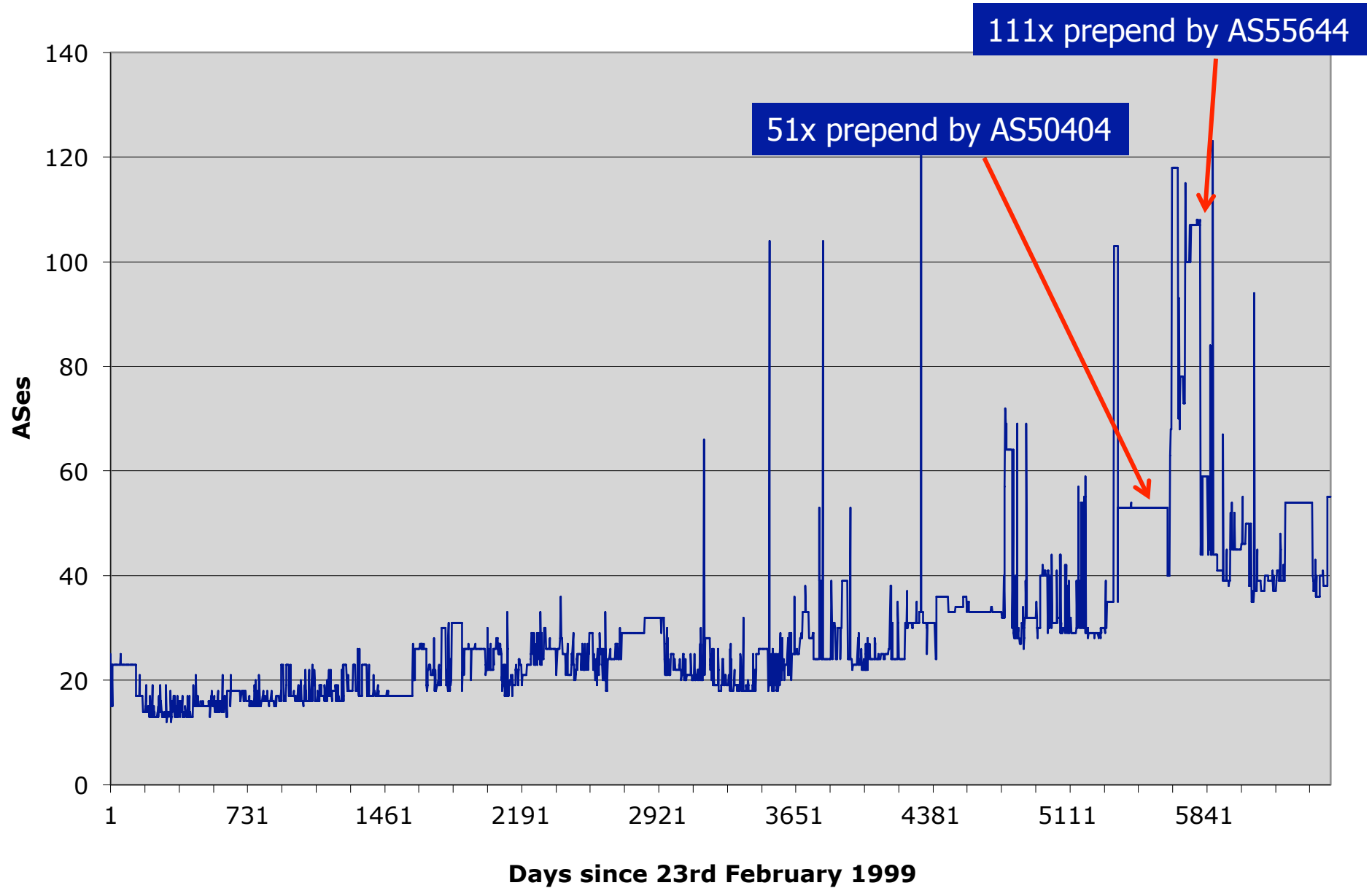


AS Announcements



— Total ASNs — Origin-only ASNs — ASN providing Transit & Origin — Transit-only ASNs

Maximum AS Path Length





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”



January 2017

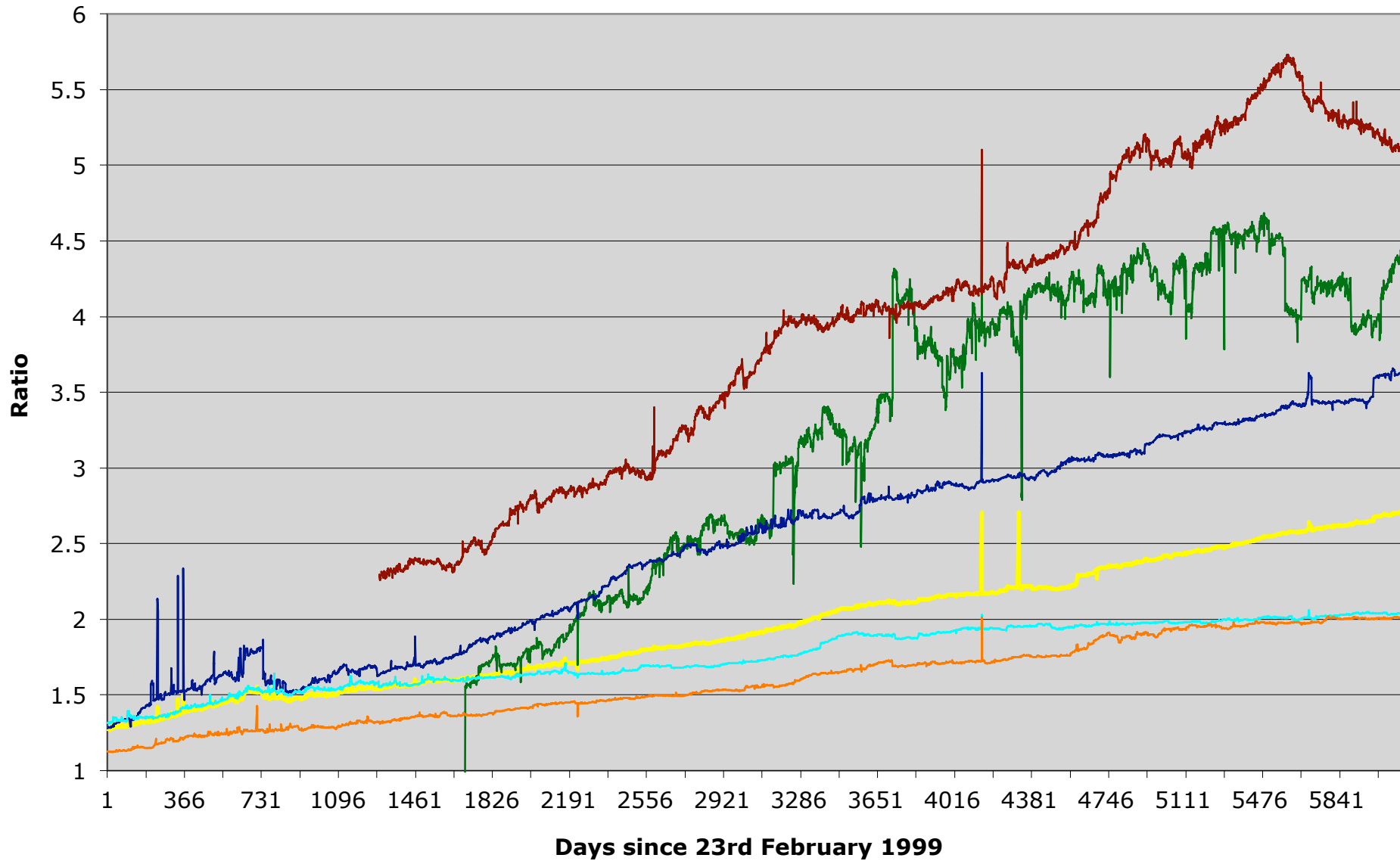
Total Prefixes

- Global BGP Table
 - 629k prefixes
- Europe & Middle East
 - 151k prefixes
- North America
 - 189k prefixes
- Asia & Pacific
 - 157k prefixes
- Africa
 - 14k prefixes
- Latin America & Caribbean
 - 64k prefixes

Deaggregation Factor

- Global Average
 - 2.84
- Europe & Middle East
 - 2.06
- North America
 - 2.11
- Asia & Pacific
 - 3.64
- Africa
 - 4.66
- Latin America & Caribbean
 - 5.08

Deaggregation: RIR Regions vs Global



Global AfriNIC APNIC ARIN LACNIC RIPE

Asia Pacific Aggregation Savings Summary

ASN	No of Nets	Savings	Description
7545	3736	3480	TPG-INTERNET-AP TPG Telecom Limited, AU
17974	2978	2907	TELKOMNET-AS2-AP PT Telekomunikasi Indo
9808	2277	2244	CMNET-GD Guangdong Mobile Communication
9829	2694	2157	BSNL-NIB National Internet Backbone, IN
4766	2732	1989	KIXS-AS-KR Korea Telecom, KR
4755	2053	1834	TATACOMM-AS TATA Communications formerl
45899	1811	1715	VNPT-AS-VN VNPT Corp, VN
7552	1501	1441	VIETEL-AS-AP Viettel Corporation, VN
9498	1479	1352	BBIL-AP BHARTI Airtel Ltd., IN
24560	1566	1318	AIRTELBROADBAND-AS-AP Bharti Airtel Ltd
4808	1648	1193	CHINA169-BJ China Unicom Beijing Provin
17488	1461	1183	HATHWAY-NET-AP Hathway IP Over Cable In
38197	1484	1180	SUNHK-DATA-AS-AP Sun Network (Hong Kong
55430	1157	1126	STARHUBINTERNET-AS-NGNBN Starhub Intern
56040	1071	1035	CMNET-GUANGDONG-AP China Mobile communi
45090	1030	1015	CNNIC-TENCENT-NET-AP Shenzhen Tencent C
9583	1552	1008	SIFY-AS-IN Sify Limited, IN
18403	934	914	FPT-AS-AP The Corporation for Financing
23969	1431	895	TOT-NET TOT Public Company Limited, TH
45528	981	851	TDN Tikona Digital Networks Pvt Ltd., I

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

Pakistan Aggregation Savings Summary

ASN	No of Nets	Savings	Description
38264	353	350	WATEEN-IMS-PK-AS-AP National WiMAX/IMS
9541	352	324	CYBERNET-AP Cyber Internet Services (Pv
23674	283	261	NAYATEL-PK Nayatel (Pvt) Ltd, PK
55714	232	220	APNIC-FIBERLINK-PK Fiberlink Pvt.Ltd, P
23966	254	209	LDN-AS-PK LINKdotNET Telecom Limited, P
45814	164	146	FARIYA-PK Fariya Networks Pvt. Ltd., PK
9260	152	131	MULTINET-AS-AP Multinet Pakistan Pvt. L
17563	139	104	NEXLINX-AS-AP Autonomous System Number
38616	98	90	WORLDCALL-AS-KHI Worldcall Telecom Limi
38710	101	89	WORLDCALL-AS-LHR Worldcall Broadband Li
38547	87	77	WITRIBE-AS-AP WITRIBE PAKISTAN LIMITED,
17557	129	68	PKTELECOM-AS-PK Pakistan Telecommunicat
58895	91	61	EBONE1-PK Ebone Network (PVT.) Limited,
23750	73	52	GERRYS-AS-AP GERRYS INFORMATION TECHNOL
7590	59	49	COMSATS Commission on Science and Techn
24435	58	43	SUPERNET-PAKISTAN-AS-AP Supernet Limite
17911	58	43	BRAINPK-AS-AP Brain Telecommunication L
38193	95	41	TWA-AS-AP Transworld Associates (Pvt.)
9387	55	38	AUGERE-PK AUGERE-Pakistan, PK,



Importance of Aggregation

- Size of routing table
 - Memory is no longer a problem
 - Routers routinely carry over 1 million prefixes
- Convergence of the Routing System
 - This is a problem
 - 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 22 January 2017 06:27 (UTC+1000)

50 Most active ASes for the past 7 days

RANK	ASN	UPDs	%	Prefixes	UPDs/Prefix	AS NAME
1	62943	216385	4.82%	188	1150.98	AS62943-BLUEBIRD-NETWORK - Bluebird Network, US
2	9829	198698	4.43%	2710	73.32	BSNL-NIB National Internet Backbone, IN
3	31148	160183	3.57%	641	249.90	FREENET-AS , UA
4	20940	100559	2.24%	3104	32.40	AKAMAI-ASN1 , US
5	34549	81568	1.82%	37	2204.54	MEER-AS meerfarbig GmbH & Co. KG, DE
6	6147	66842	1.49%	1385	48.26	Telefonica del Peru S.A.A., PE
7	29909	66235	1.48%	19	3486.05	LESSE - MetroOptic, Inc., CA
8	16532	56054	1.25%	12	4671.17	ASB2B2C - B2B2C Inc, CA
9	45899	46506	1.04%	1861	24.99	VNPT-AS-VN VNPT Corp, VN
10	135480	43872	0.98%	7	6267.43	IDNIC-AGTI-AS-ID PT. Arjuna Global Teknologi Indonesia, ID
11	34164	38703	0.86%	126	307.17	AKAMAI-LON , GB
12	45718	36834	0.82%	10	3683.40	IDNIC-ID Indonesia Network Information Center, ID
13	54058	35665	0.79%	7	5095.00	KOBO - Rakuten Inc, US
14	9808	31814	0.71%	2313	13.75	CMNET-GD Guangdong Mobile Communication Co.Ltd., CN
15	26938	30588	0.68%	7	4369.71	COMPUSOURCE - CompuSOURCE Communications Corp., US
16	9299	29527	0.66%	819	36.05	IPG-AS-AP Philippine Long Distance Telephone Company, PH
17	27738	29353	0.65%	787	37.30	Ecuadortelecom S.A., EC
18	262948	27520	0.61%	6	4586.67	LD Telecomunicações LTDA, BR
19	7453	27043	0.60%	15	1802.87	ACCELERATION - ACCELERATED DATA WORKS, INC., US
20	39891	26254	0.58%	3334	7.87	ALJAWWALSTC-AS , SA
21	7552	26238	0.58%	1501	17.48	VIETEL-AS-AP Viettel Corporation, VN
22	16570	25529	0.57%	71	359.56	TELOIP-SW-ASN - AgniCorp Inc., CA
23	31293	25477	0.57%	11	2316.09	ITNSGLOBAL-AS , BG
24	48115	25460	0.57%	6	4243.33	DGM-AS Sofia, Bulgaria, BG
25	13118	25065	0.56%	99	253.18	ASN-YARTELECOM PJSC Rostelecom, RU
26	40805	24784	0.55%	29	854.62	JMFSOLUTIONS - JMF Solutions, Inc, US

50 Most active Prefixes for the past 7 days

RANK	PREFIX	UPDs	%	Origin AS -- AS NAME
1	110.170.17.0/24	22200	0.48%	134438 -- AIRAAIFUL-AS-AP Aira & Aiful Public Company Limited, TH
2	93.181.192.0/19	21699	0.46%	13118 -- ASN-YARTELECOM PJSC Rostelecom, RU
3	193.243.214.0/24	19752	0.42%	8386 -- KOCNET , TR
4	103.76.200.0/22	14654	0.31%	135480 -- IDNIC-AGTI-AS-ID PT. Arjuna Global Teknologi Indonesia, ID
5	103.76.202.0/23	14613	0.31%	135480 -- IDNIC-AGTI-AS-ID PT. Arjuna Global Teknologi Indonesia, ID
6	103.76.200.0/23	14589	0.31%	135480 -- IDNIC-AGTI-AS-ID PT. Arjuna Global Teknologi Indonesia, ID
7	168.228.116.0/24	13748	0.29%	262948 -- LD Telecomunicações LTDA, BR
8	168.228.117.0/24	13745	0.29%	262948 -- LD Telecomunicações LTDA, BR
9	189.201.190.0/23	13099	0.28%	28438 -- Metro Net, S.A.P.I. de C.V., MX
10	117.103.64.0/24	12340	0.26%	45718 -- IDNIC-ID Indonesia Network Information Center, ID
11	59.153.80.0/24	12298	0.26%	45718 -- IDNIC-ID Indonesia Network Information Center, ID
12	59.153.81.0/24	12196	0.26%	45718 -- IDNIC-ID Indonesia Network Information Center, ID
13	187.63.254.0/24	9640	0.21%	28170 -- Wal-Mart Brasil LTDA, BR
14	143.28.229.0/24	9091	0.19%	11003 -- PANDG - The Procter and Gamble Company, US 15442 -- PG-EUROPE , BE
15	121.200.53.0/24	8596	0.18%	45284 -- WLSNET-AS-AP Wireline Solution India Pvt Ltd., IN
16	66.19.194.0/24	8519	0.18%	6316 -- AS-PAETEC-NET - PaeTec Communications, Inc., US
17	199.101.233.0/24	7963	0.17%	12272 -- MEDATA-PROD-AS - Medata Inc., US
18	223.239.16.0/20	7952	0.17%	45609 -- BHARTI-MOBILITY-AS-AP Bharti Airtel Ltd. AS for GPRS Service, IN
19	111.11.247.0/24	7901	0.17%	9808 -- CMNET-GD Guangdong Mobile Communication Co.Ltd., CN
20	223.239.0.0/23	7788	0.17%	45609 -- BHARTI-MOBILITY-AS-AP Bharti Airtel Ltd. AS for GPRS Service, IN
21	202.56.215.0/24	7771	0.17%	24560 -- AIRTELBROADBAND-AS-AP Bharti Airtel Ltd., Telemedia Services, IN
22	216.238.254.0/23	7684	0.16%	13904 -- COSLINK - Cherryland Services Inc, US
23	41.209.8.0/24	7502	0.16%	9129 -- KE-NET2000, ZA
24	185.17.130.0/24	7493	0.16%	196742 -- EKLAN-AS , RU
25	111.11.218.0/24	7473	0.16%	9808 -- CMNET-GD Guangdong Mobile Communication Co.Ltd., CN
26	111.11.217.0/24	7469	0.16%	9808 -- CMNET-GD Guangdong Mobile Communication Co.Ltd., CN
27	111.11.219.0/24	7465	0.16%	9808 -- CMNET-GD Guangdong Mobile Communication Co.Ltd., CN
28	94.73.56.0/21	7155	0.15%	25211 -- TELECOMASET-AS , BG
29	198.148.151.0/24	6880	0.15%	3832 -- CINE-NET - Cinenet Communications, US
30	217.199.157.0/24	6398	0.14%	9129 -- KE-NET2000, ZA
31	64.68.251.0/24	6396	0.14%	13904 -- COSLINK - Cherryland Services Inc, US



Observations

- Range of operational “practices” between RIR regions
 - Deaggregation by newer ISPs & developing regions is growing rapidly
 - Is harming the **entire** Internet
- RIPE-399 is only a recommendation
 - Hopefully all the RIRs will include pointers with each address allocation
 - Hopefully more ISPs will pay attention to it
 - Training is there — most ISPs choose to ignore it

Internet Routing Table Analysis Update



Questions?