

Internet IPv4 Routing Table Analysis Update

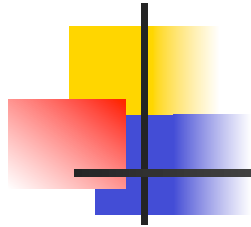


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BTNOG 3

18th November 2016

Thimphu, Bhutan



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 17 November 2016

BGP routing table entries examined:	622868
Prefixes after maximum aggregation (per Origin AS):	221022
Deaggregation factor:	2.82
Unique aggregates announced (without unneeded subnets):	302173
Total ASes present in the Internet Routing Table:	55225
Prefixes per ASN:	11.28
Origin-only ASes present in the Internet Routing Table:	36332
Origin ASes announcing only one prefix:	15327
Transit ASes present in the Internet Routing Table:	6541
Transit-only ASes present in the Internet Routing Table:	164
Average AS path length visible in the Internet Routing Table:	4.3
Max AS path length visible:	36
Max AS path prepend of ASN (55644)	31
Prefixes from unregistered ASNs in the Routing Table:	67
Unregistered ASNs in the Routing Table:	21
Number of 32-bit ASNs allocated by the RIRs:	16149
Number of 32-bit ASNs visible in the Routing Table:	12352
Prefixes from 32-bit ASNs in the Routing Table:	50018
Number of bogon 32-bit ASNs visible in the Routing Table:	369
Special use prefixes present in the Routing Table:	0
Prefixes being announced from unallocated address space:	427
Number of addresses announced to Internet:	2831619620
Equivalent to 168 /8s, 199 /16s and 22 /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:	98.3
Total number of prefixes smaller than registry allocations:	205038

APNIC Region

Prefixes being announced by APNIC Region ASes:	157504
Total APNIC prefixes after maximum aggregation:	42843
APNIC Deaggregation factor:	3.68
Prefixes being announced from the APNIC address blocks:	171475
Unique aggregates announced from the APNIC address blocks:	70214
APNIC Region origin ASes present in the Internet Routing Table:	5183
APNIC Prefixes per ASN:	33.08
APNIC Region origin ASes announcing only one prefix:	1145
APNIC Region transit ASes present in the Internet Routing Table:	948
Average APNIC Region AS path length visible:	4.3
Max APNIC Region AS path length visible:	35
Number of APNIC region 32-bit ASNs visible in the Routing Table:	2483
Number of APNIC addresses announced to Internet:	759791940
Equivalent to 45 /8s, 73 /16s and 129 /24s	

Global per AS prefix count summary

ASN	No of nets	/20 equiv	Max Agg	Description
4538	5543	4190	74	ERX-CERNET-BKB China Education and Rese
7545	3612	390	249	TPG-INTERNET-AP TPG Telecom Limited, AU
22773	3554	2967	150	ASN-CXA-ALL-CCI-22773-RDC - Cox Communi
10620	3529	544	167	Telmex Colombia S.A., CO
39891	3330	170	16	ALJAWWALSTC-AS , SA
6327	3155	1333	82	SHAW - Shaw Communications Inc., CA
17974	2964	905	71	TELKOMNET-AS2-AP PT Telekomunikasi Indo
20940	2943	1115	2081	AKAMAI-ASN1 , US
9829	2708	1500	539	BSNL-NIB National Internet Backbone, IN
4766	2695	11132	739	KIXS-AS-KR Korea Telecom, KR
8151	2288	3367	553	Uninet S.A. de C.V., MX
9808	2224	8698	32	CMNET-GD Guangdong Mobile Communication
18566	2197	405	110	MEGAPATH5-US - MegaPath Corporation, US
6389	2095	3671	39	BELLSOUTH-NET-BLK - BellSouth.net Inc.,
4755	2045	428	216	TATACOMM-AS TATA Communications formerl
34984	1990	327	364	TELLCOM-AS , TR
20115	1948	2003	406	CHARTER-NET-HKY-NC - Charter Communicat
30036	1767	334	368	MEDIACOM-ENTERPRISE-BUSINESS - Mediacom
4808	1746	2278	510	CHINA169-BJ China Unicom Beijing Provin
209	1743	5069	657	CENTURYLINK-US-LEGACY-QWEST - Qwest Com

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	/11:102	/12:274
/13:522	/14:1050	/15:1786	/16:13141	/17:7855	/18:13077
/19:25557	/20:38340	/21:40884	/22:72204	/23:60753	/24:345994
/25:461	/26:362	/27:303	/28:59	/29:34	/30:12
/31:1	/32:32				

November 2016 ↑

November 2014↓

Number of prefixes announced by prefix length

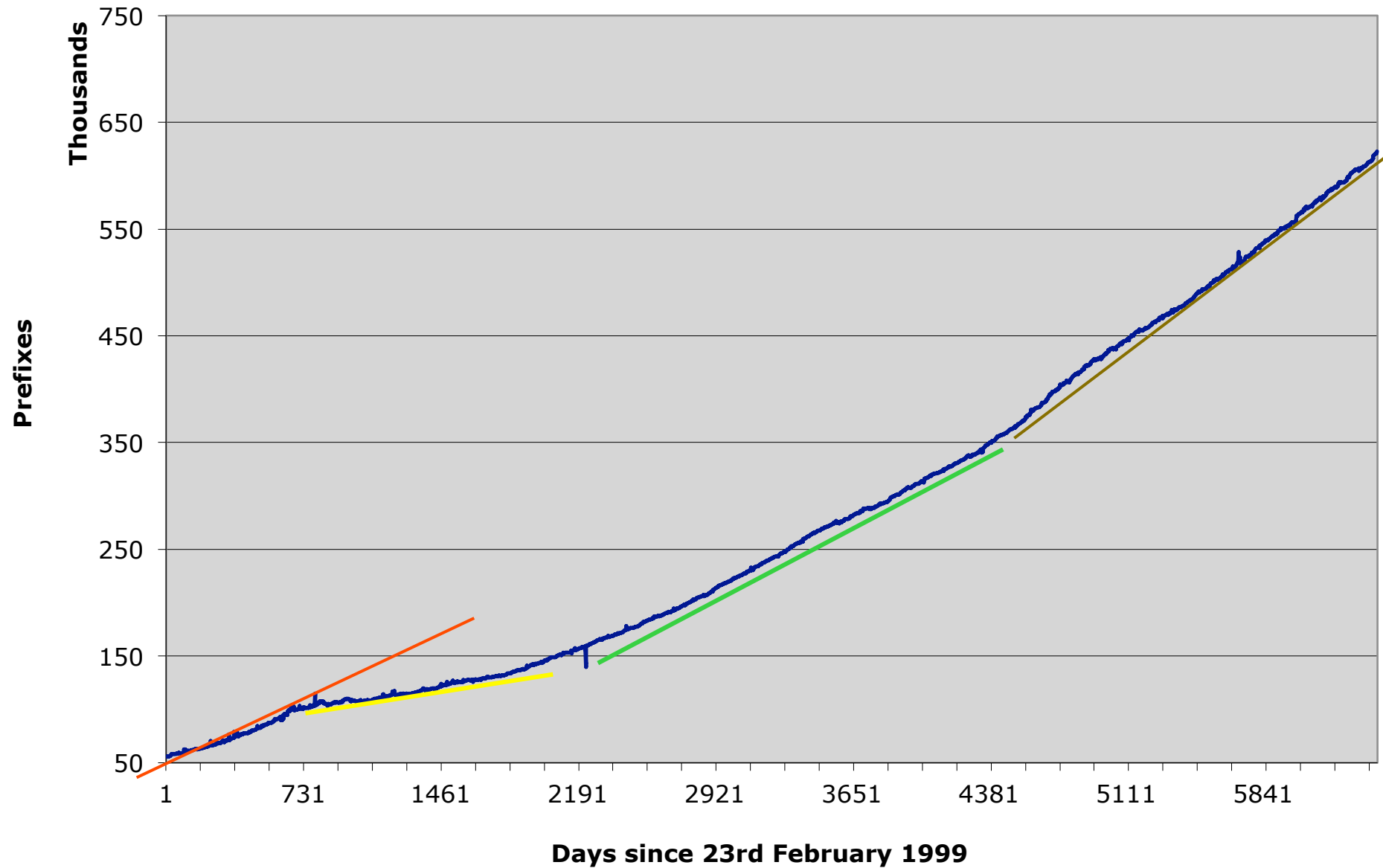
/1:0	/2:0	/3:0	/4:0	/5:0	/6:0
/7:0	/8:16	/9:12	/10:31	/11:90	/12:262
/13:500	/14:1009	/15:1721	/16:13038	/17:7246	/18:12085
/19:25508	/20:36623	/21:37903	/22:55967	/23:49000	/24:279550
/25:1126	/26:1093	/27:703	/28:15	/29:19	/30:11
/31:0	/32:12				

Prefixes Smaller than Registry Allocations

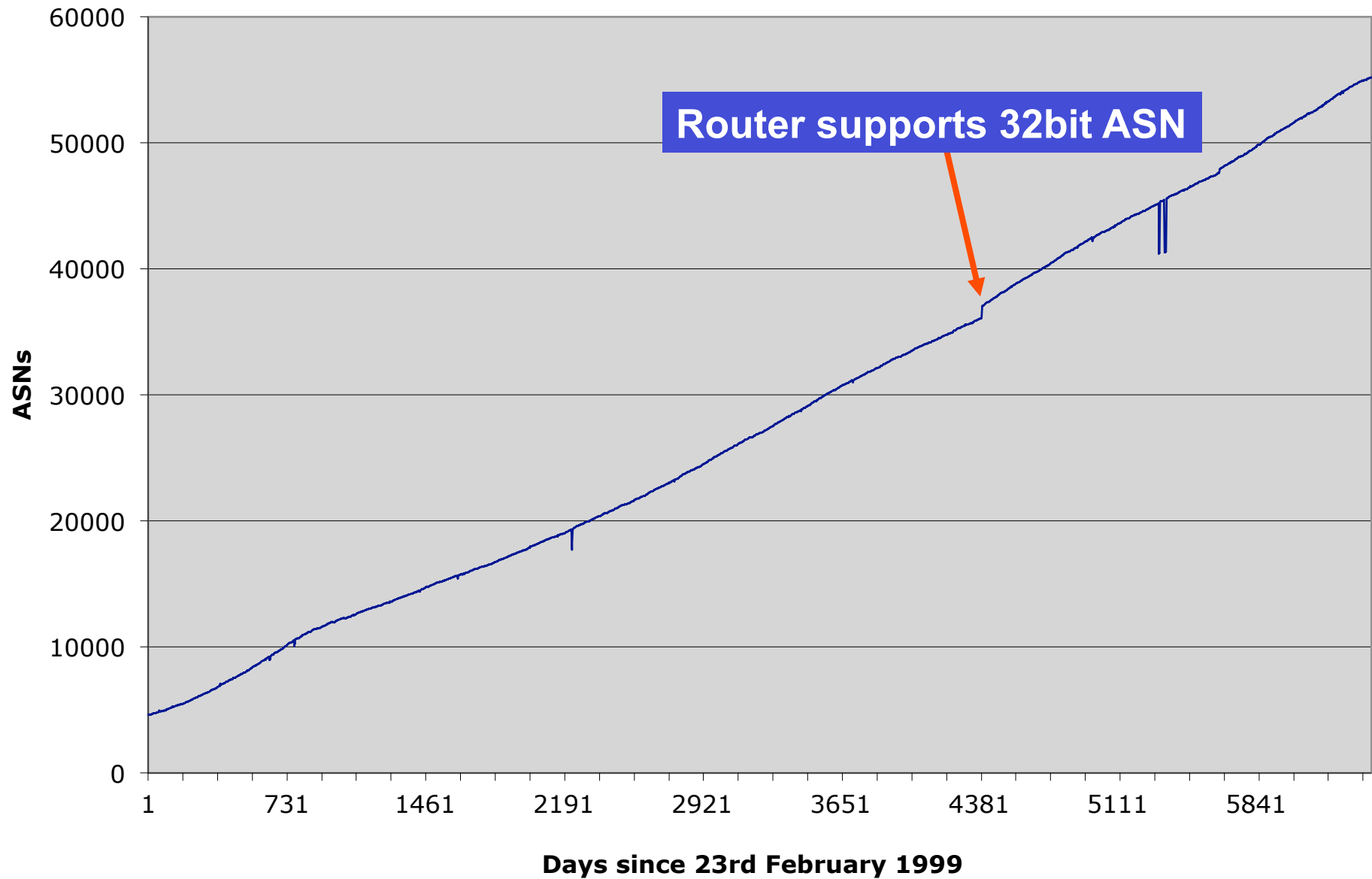
ASN	No of nets	Total ann.	Description
6327	2952	3155	SHAW - Shaw Communications Inc., CA
39891	2896	3330	ALJAWWALSTC-AS , SA
22773	2766	3554	ASN-CXA-ALL-CCI-22773-RDC - Cox Communi
18566	2089	2197	MEGAPATH5-US - MegaPath Corporation, US
30036	1584	1767	MEDIACOM-ENTERPRISE-BUSINESS - Mediacom
10620	1443	3529	Telmex Colombia S.A., CO
6389	1393	2095	BELLSOUTH-NET-BLK - BellSouth.net Inc.,
13188	1336	1583	TRIOLAN , UA
6983	1323	1677	ITCDELTA - Earthlink, Inc., US
34984	1274	1990	TELLCOM-AS , TR
11492	1254	1344	CABLEONE - CABLE ONE, INC., US
9121	1032	1440	TTNET , TR
6849	969	1142	UKRTELNET , UA
6147	876	1289	Telefonica del Peru S.A.A., PE
209	874	1743	CENTURYLINK-US-LEGACY-QWEST - Qwest Com
6503	844	1486	Axtel, S.A.B. de C.V., MX
7155	840	966	VIASAT-SP-BACKBONE - ViaSat,Inc., US
20940	831	2943	AKAMAI-ASN1 , US
13977	830	864	CTELCO - FAIRPOINT COMMUNICATIONS, INC.
11830	819	1353	Instituto Costarricense de Electricidad

AfriNIC APNIC ARIN LACNIC RIPE NCC

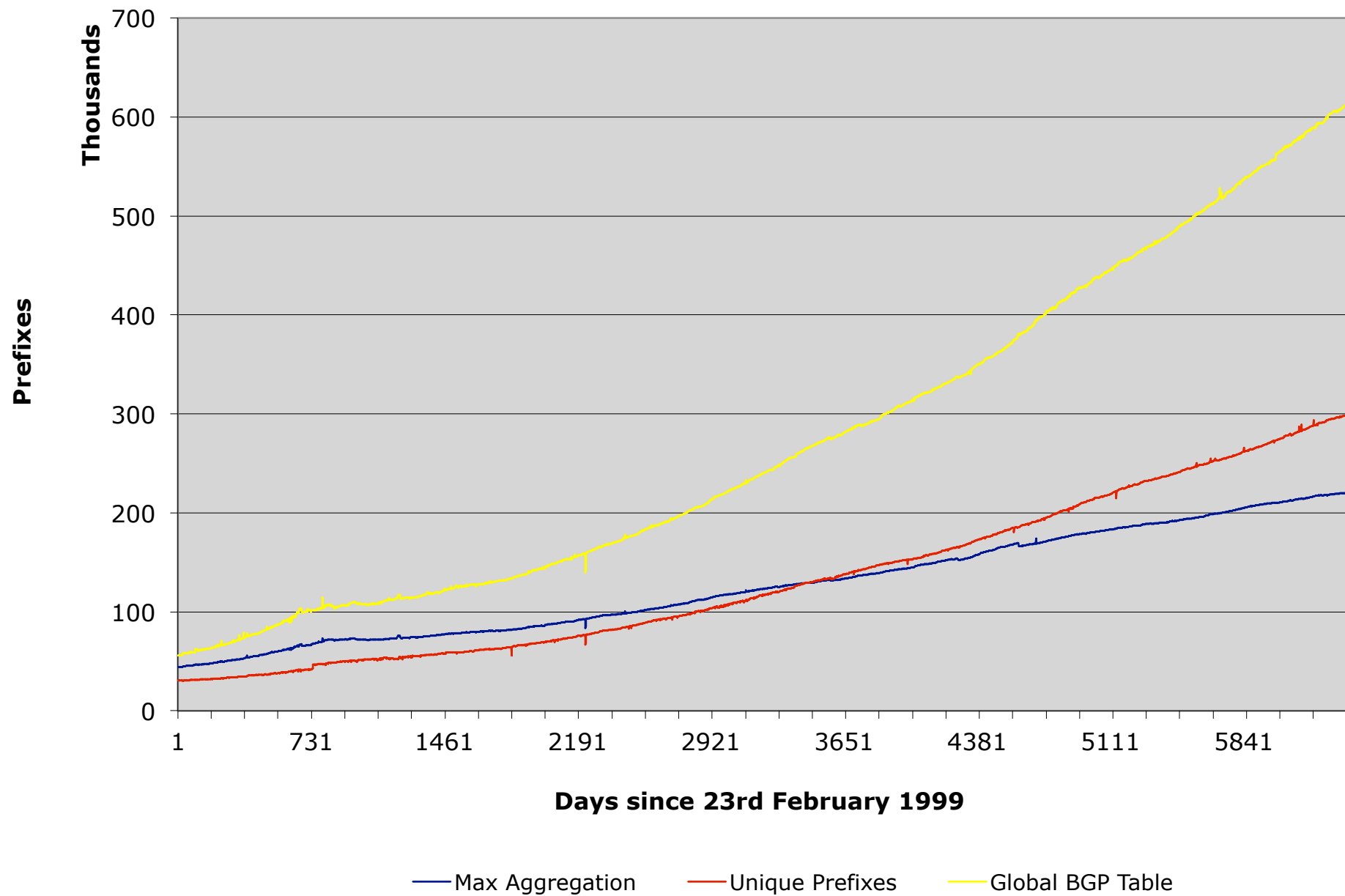
BGP Routing Table



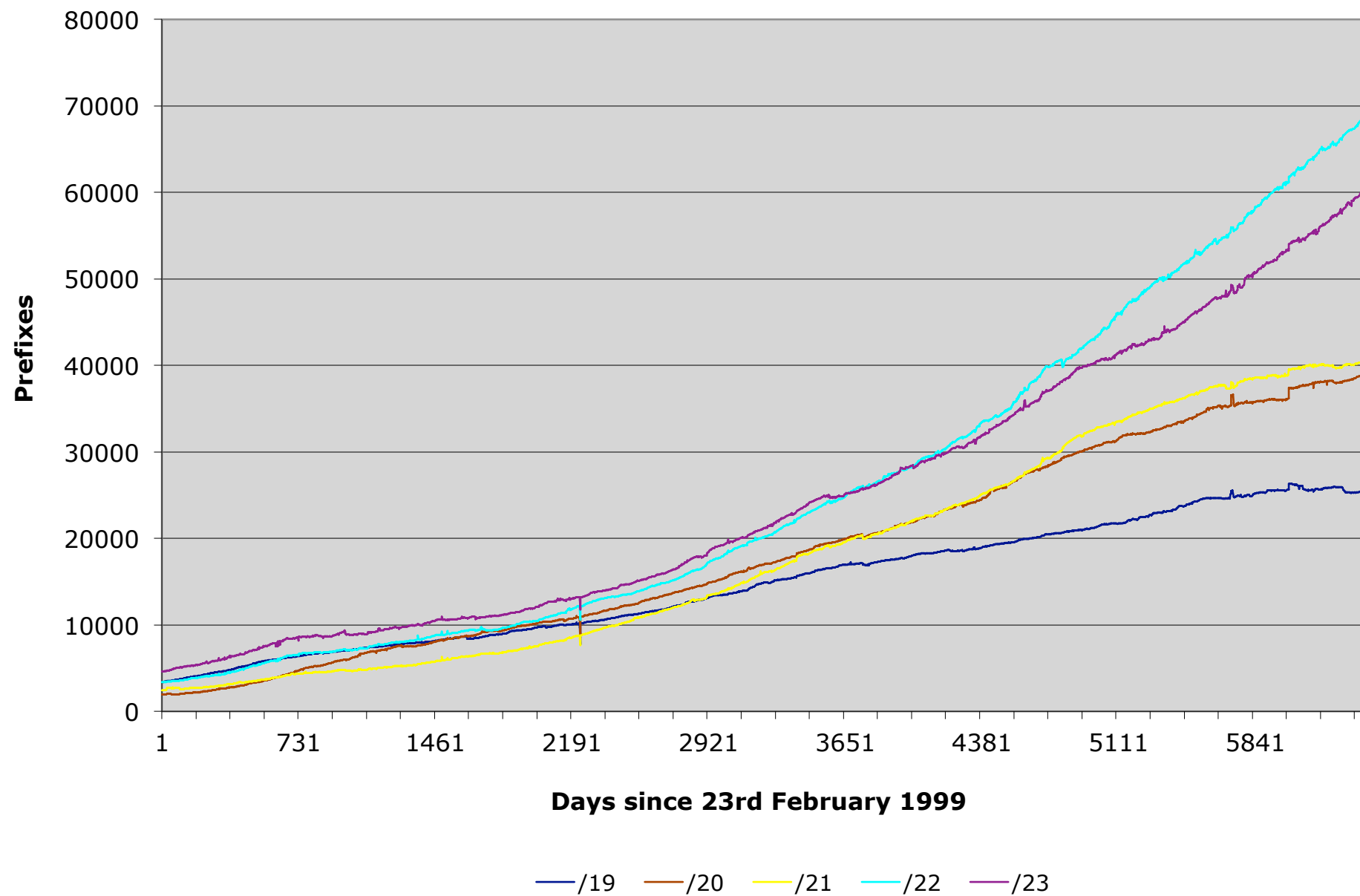
AS Growth



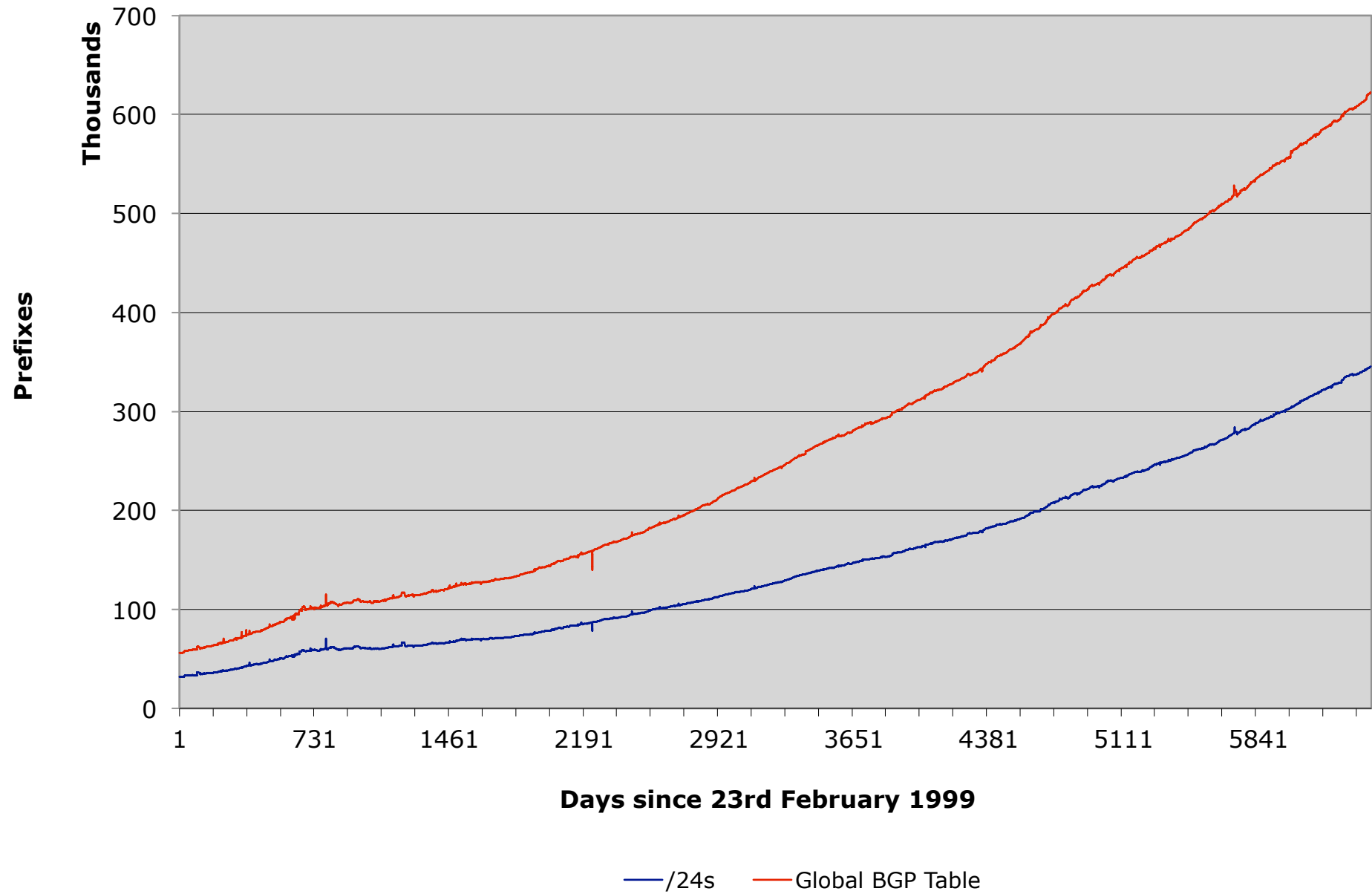
Max Aggregation vs Unique Prefixes



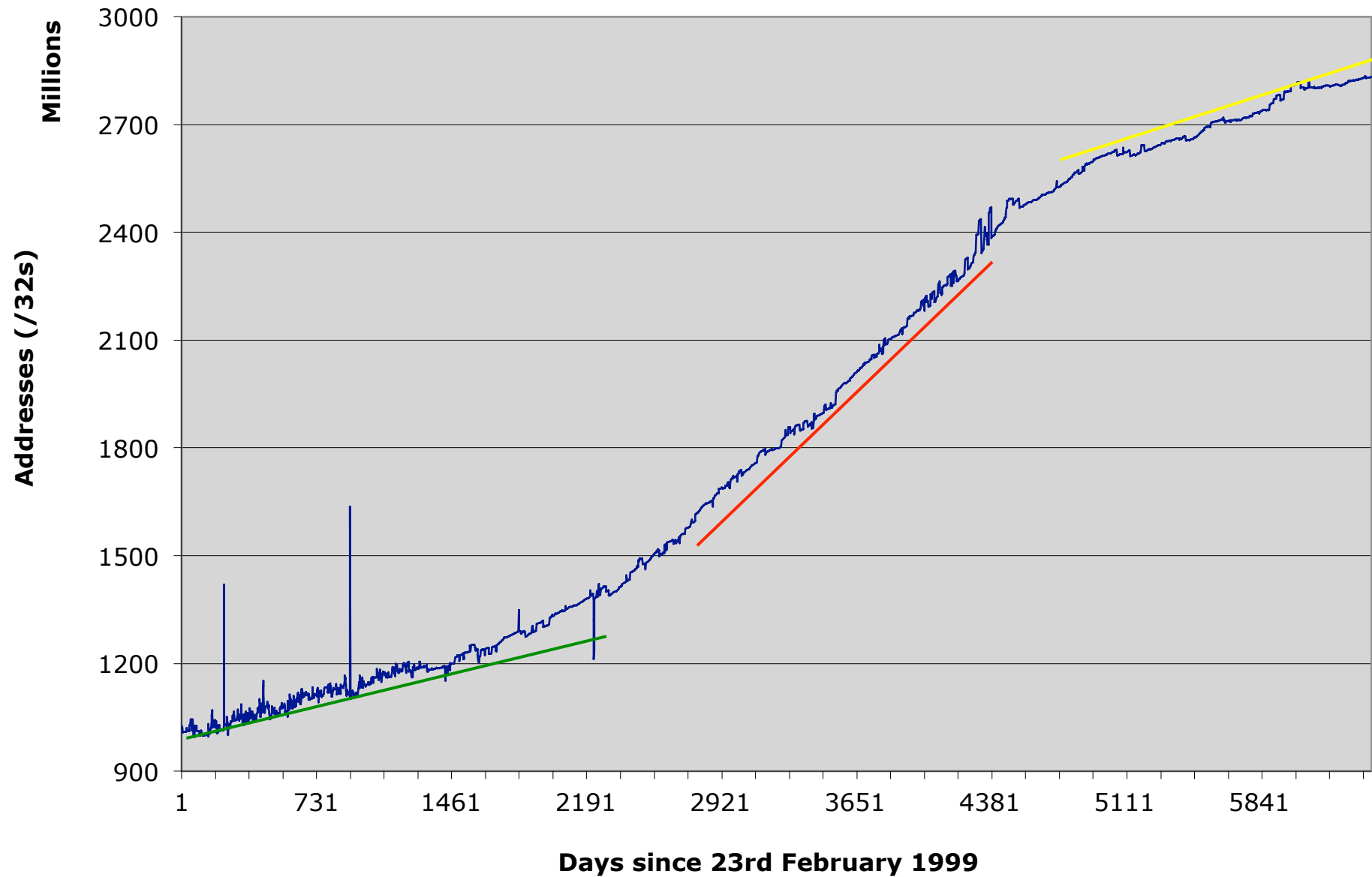
Prefix sizes announced



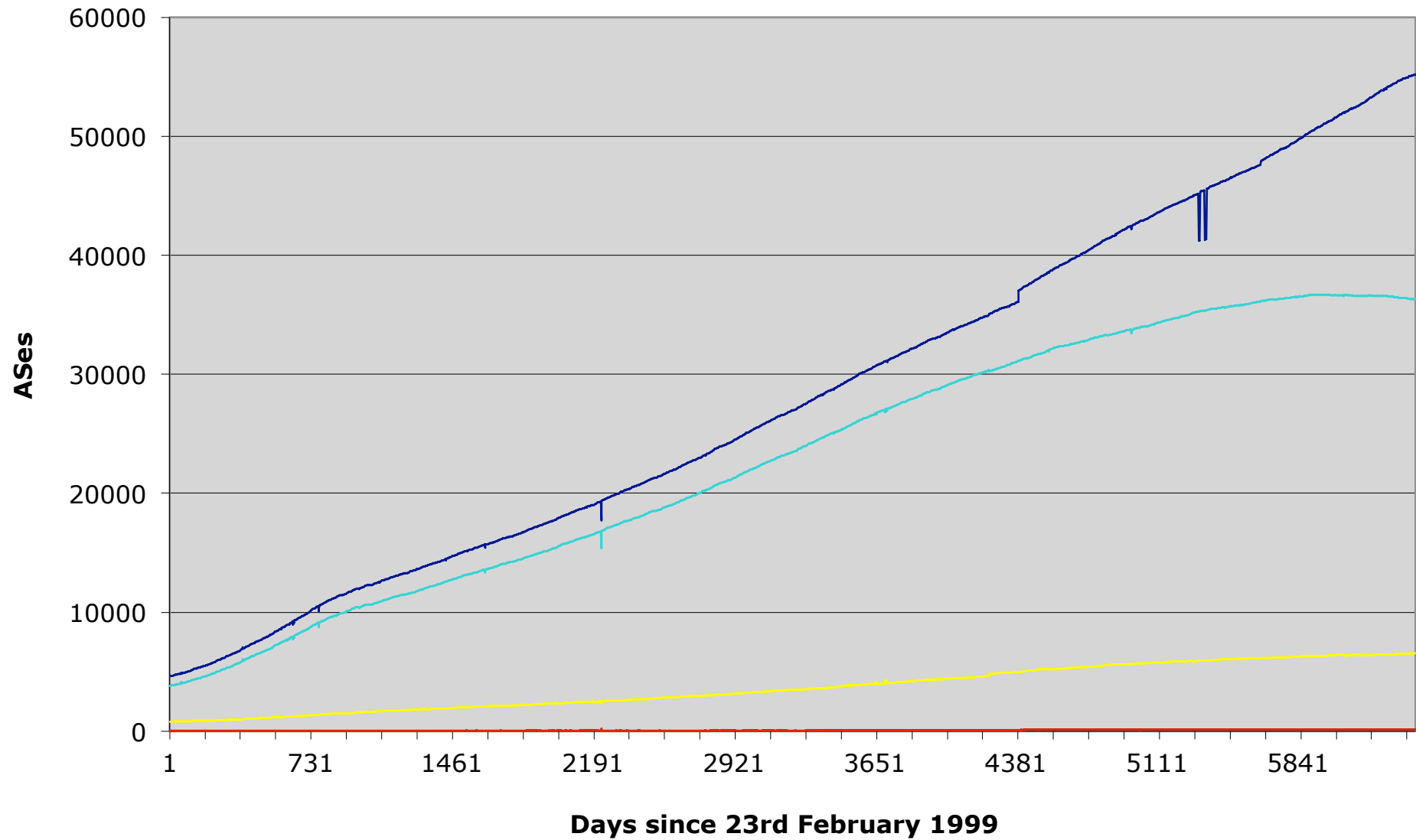
/24s announced



Address Space announced



AS Announcements



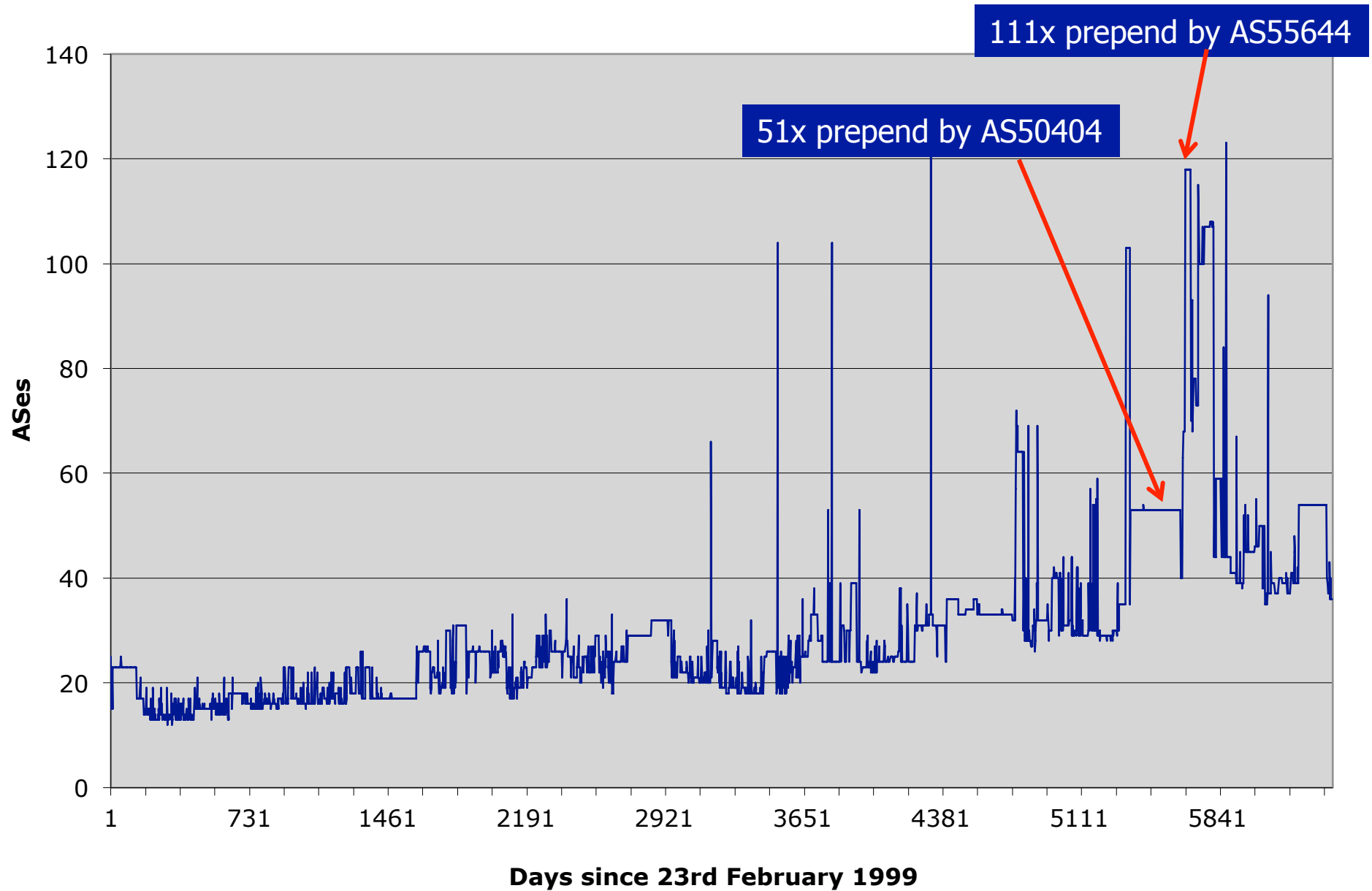
— Total ASNs

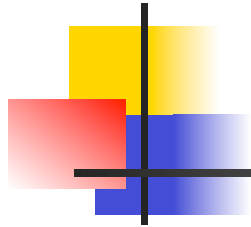
— Origin-only ASNs

— ASN providing Transit & Origin

— Transit-only ASNs

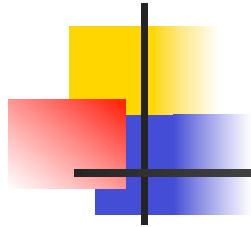
Maximum AS Path Length





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”



November 2016

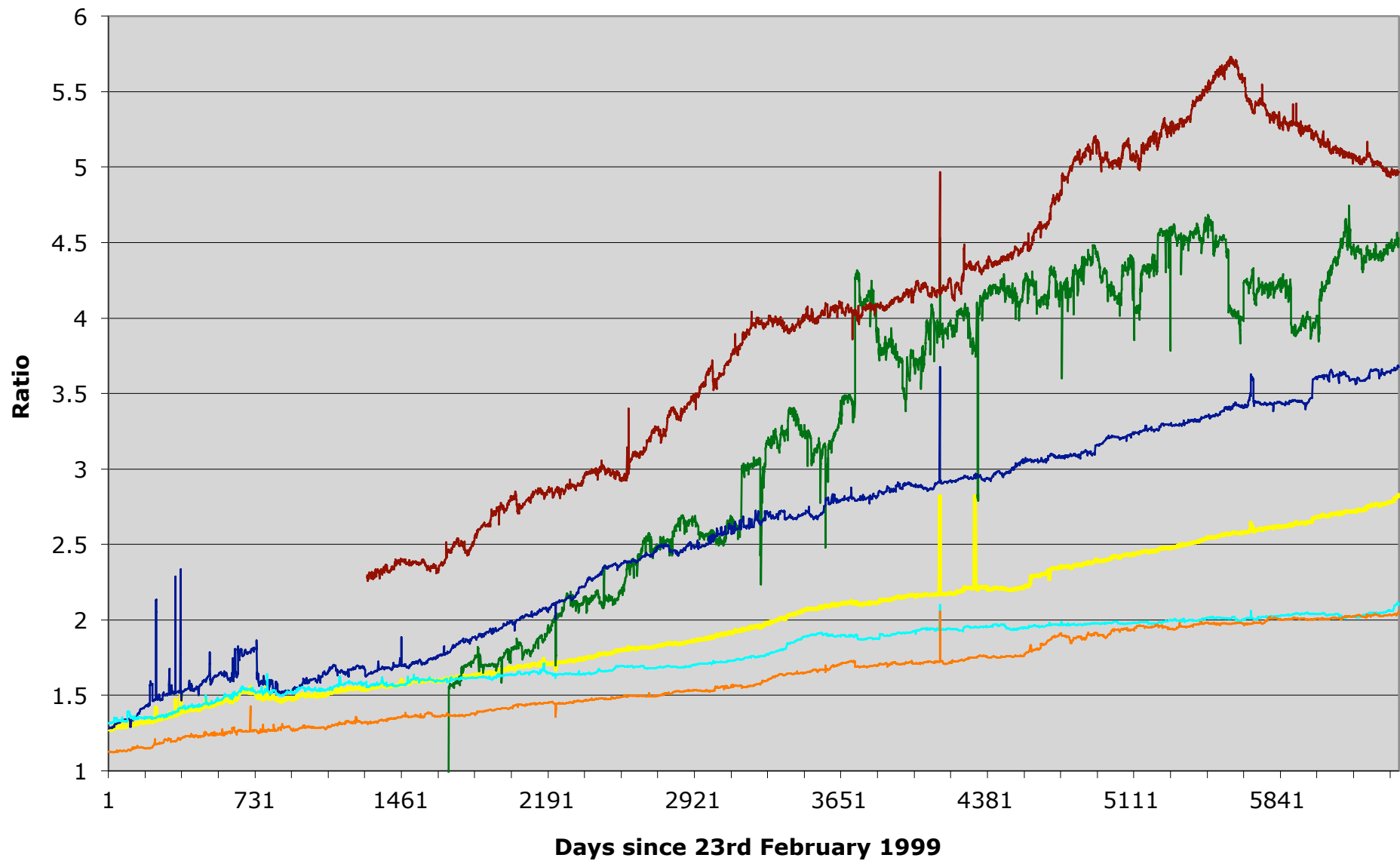
Total Prefixes

- Global BGP Table
 - 623k prefixes
- Europe & Middle East
 - 149k prefixes
- North America
 - 188k prefixes
- Asia & Pacific
 - 158k prefixes
- Africa
 - 15k prefixes
- Latin America & Caribbean
 - 63k prefixes

Deaggregation Factor

- Global Average
 - 2.82
- Europe & Middle East
 - 2.05
- North America
 - 2.10
- Asia & Pacific
 - 3.68
- Africa
 - 4.53
- Latin America & Caribbean
 - 4.97

Deaggregation: RIR Regions vs Global

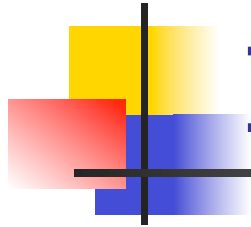


Global AfriNIC APNIC ARIN LACNIC RIPE

APNIC Region Aggregation Savings Summary

ASN	No of Nets	Savings	Description
7545	3612	3363	TPG-INTERNET-AP TPG Telecom Limited, AU
17974	2964	2893	TELKOMNET-AS2-AP PT Telekomunikasi Indo
9808	2224	2192	CMNET-GD Guangdong Mobile Communication
9829	2708	2169	BSNL-NIB National Internet Backbone, IN
4766	2695	1956	KIXS-AS-KR Korea Telecom, KR
4755	2045	1829	TATACOMM-AS TATA Communications formerl
45899	1696	1604	VNPT-AS-VN VNPT Corp, VN
7552	1415	1361	VIETEL-AS-AP Viettel Corporation, VN
56040	1390	1357	CMNET-GUANGDONG-AP China Mobile communi
9498	1461	1341	BBIL-AP BHARTI Airtel Ltd., IN
24560	1564	1335	AIRTELBROADBAND-AS-AP Bharti Airtel Ltd
4808	1746	1236	CHINA169-BJ China Unicom Beijing Provin
38197	1486	1181	SUNHK-DATA-AS-AP Sun Network (Hong Kong
17488	1471	1180	HATHWAY-NET-AP Hathway IP Over Cable In
18403	1096	1078	FPT-AS-AP The Corporation for Financing
55430	1075	1047	STARHUBINTERNET-AS-NGNBN Starhub Intern
9583	1535	1001	SIFY-AS-IN Sify Limited, IN
9299	960	882	IPG-AS-AP Philippine Long Distance Tele
23969	1382	867	TOT-NET TOT Public Company Limited, TH
45090	862	846	CNNIC-TENCENT-NET-AP Shenzhen Tencent C

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



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

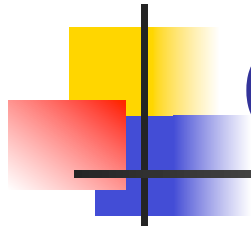
The BGP Instability Report is updated daily. This report was generated on 17 November 2016 07:01 (UTC+1000)

50 Most active ASes for the past 7 days

RANK	ASN	UPDs	%	Prefixes	UPDs/Prefix	AS NAME
1	20657	188142	6.76%	16	11758.88	ATLANTIS Sofia, Bulgaria, BG
2	9829	160925	5.78%	2713	59.32	BSNL-NIB National Internet Backbone, IN
3	58985	89345	3.21%	44	2030.57	FHNC-HK GS Network (Hong Kong) Ltd., HK
4	45899	60893	2.19%	1707	35.67	VNPT-AS-VN VNPT Corp, VN
5	39891	33977	1.22%	3330	10.20	ALJAWWALSTC-AS , SA
6	45223	28855	1.04%	11	2623.18	WIN-AS-TH-AP World Internetwork Co.,Ltd , Thailand., TH
7	6327	22489	0.81%	3210	7.01	SHAW - Shaw Communications Inc., CA
8	13118	22332	0.80%	98	227.88	ASN-YARTELECOM PJSC Rostelecom, RU
9	24342	21617	0.78%	126	171.56	BRAC-BDMAIL-AS-BD BRAC BDMail Network Ltd., BD
10	134438	19058	0.68%	1	19058.00	AIRAAIFUL-AS-AP Aira & Aiful Public Company Limited, TH
11	9129	18411	0.66%	72	255.71	KE-NET2000, ZA
12	27738	16446	0.59%	786	20.92	Ecuadortelecom S.A., EC
13	17408	15178	0.55%	86	176.49	ABOVE-AS-AP AboveNet Communications Taiwan, TW
14	10620	15071	0.54%	3529	4.27	Telmex Colombia S.A., CO
15	36903	14084	0.51%	687	20.50	MT-MPLS, MA
16	60725	13618	0.49%	38	358.37	O3B-AS O3b Networks - Internet Service Provider operating a Medium Earth Orbit satellite constellation, JE
17	7643	13363	0.48%	385	34.71	VNPT-AS-VN Vietnam Posts and Telecommunications (VNPT), VN
18	25211	12174	0.44%	142	85.73	TELECOMASET-AS , BG
19	13904	12006	0.43%	132	90.95	COSLINK - Cherryland Services Inc, US
20	14638	11878	0.43%	517	22.97	LCPR-HSD - Liberty Cablevision of Puerto Rico LTD, PR
21	15468	11806	0.42%	265	44.55	KLGELECS-AS 38, Teatralnaya st., RU
22	197068	11476	0.41%	15	765.07	QRATOR , RU
23	23956	11351	0.41%	93	122.05	AMBERIT-BD-AS AmberIT Limited, BD
24	38017	10864	0.39%	22	493.82	GLOBAL-TRANSIT-AS-SILBD Route object of Square InformatiX Ltd, BD
25	9299	10267	0.37%	972	10.56	IPG-AS-AP Philippine Long Distance Telephone Company, PH
26	24560	10065	0.36%	1564	6.44	AIRTELBROADBAND-AS-AP Bharti Airtel Ltd., Telemedia Services, IN

50 Most active Prefixes for the past 7 days

RANK	PREFIX	UPDs	%	Origin AS -- AS NAME
1	93.181.192.0/19	19428	0.66%	13118 -- ASN-YARTELECOM PJSC Rostelecom, RU
2	110.170.17.0/24	19058	0.65%	134438 -- AIRAAIFUL-AS-AP Aira & Aiful Public Company Limited, TH
3	194.79.13.0/24	18227	0.62%	20657 -- ATLANTIS Sofia, Bulgaria, BG
4	194.79.12.0/24	18180	0.62%	20657 -- ATLANTIS Sofia, Bulgaria, BG
5	88.80.128.0/24	17854	0.61%	20657 -- ATLANTIS Sofia, Bulgaria, BG 47226 -- NEXIS , BG
6	194.79.15.0/24	17298	0.59%	20657 -- ATLANTIS Sofia, Bulgaria, BG
7	88.80.131.0/24	17178	0.59%	20657 -- ATLANTIS Sofia, Bulgaria, BG
8	195.68.215.0/24	15922	0.54%	20657 -- ATLANTIS Sofia, Bulgaria, BG
9	195.68.214.0/24	15899	0.54%	20657 -- ATLANTIS Sofia, Bulgaria, BG
10	194.79.14.0/24	15857	0.54%	20657 -- ATLANTIS Sofia, Bulgaria, BG
11	88.80.152.0/21	15834	0.54%	20657 -- ATLANTIS Sofia, Bulgaria, BG
12	88.80.136.0/21	15810	0.54%	20657 -- ATLANTIS Sofia, Bulgaria, BG
13	88.80.134.0/23	15790	0.54%	20657 -- ATLANTIS Sofia, Bulgaria, BG
14	185.94.110.0/24	11475	0.39%	197068 -- QRATOR , RU
15	43.255.120.0/24	11189	0.38%	58985 -- FHNC-HK GS Network (Hong Kong) Ltd., HK
16	103.30.79.0/24	11106	0.38%	58985 -- FHNC-HK GS Network (Hong Kong) Ltd., HK
17	43.254.164.0/24	11093	0.38%	58985 -- FHNC-HK GS Network (Hong Kong) Ltd., HK
18	103.195.105.0/24	11080	0.38%	58985 -- FHNC-HK GS Network (Hong Kong) Ltd., HK
19	103.195.107.0/24	11069	0.38%	58985 -- FHNC-HK GS Network (Hong Kong) Ltd., HK
20	103.228.111.0/24	11003	0.38%	58985 -- FHNC-HK GS Network (Hong Kong) Ltd., HK
21	103.24.219.0/24	10962	0.37%	58985 -- FHNC-HK GS Network (Hong Kong) Ltd., HK
22	41.209.8.0/24	10838	0.37%	9129 -- KE-NET2000, ZA
23	43.255.123.0/24	10268	0.35%	58985 -- FHNC-HK GS Network (Hong Kong) Ltd., HK
24	180.128.0.0/23	9620	0.33%	45223 -- WIN-AS-TH-AP World Internetwork Co.,Ltd , Thailand., TH
25	180.128.16.0/23	9619	0.33%	45223 -- WIN-AS-TH-AP World Internetwork Co.,Ltd , Thailand., TH
26	180.128.18.0/23	9616	0.33%	45223 -- WIN-AS-TH-AP World Internetwork Co.,Ltd , Thailand., TH
27	65.217.233.0/24	8720	0.30%	32295 -- DESIGNCOLLECTIVE - Design Collective, Inc., US
28	8.34.145.0/24	8080	0.28%	13600 -- CONVO - Convo, US
29	166.64.5.0/24	7620	0.26%	10223 -- UECOMM-AU Uecomm Ltd, AU
30	187.63.254.0/24	7461	0.25%	28170 -- Wal-Mart Brasil LTDA, BR
31	88.80.129.0/24	7409	0.25%	20657 -- ATLANTIS Sofia, Bulgaria, BG



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?