

Internet IPv4 Routing Table Analysis Update



Philip Smith
SANOG 30
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Gurgaon, India



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 9th July 2017

BGP routing table entries examined:	653793
Prefixes after maximum aggregation (per Origin AS):	254290
Deaggregation factor:	2.57
Unique aggregates announced (without unneeded subnets):	315380
Total ASes present in the Internet Routing Table:	57716
Prefixes per ASN:	11.33
Origin-only ASes present in the Internet Routing Table:	49946
Origin ASes announcing only one prefix:	22051
Transit ASes present in the Internet Routing Table:	7770
Transit-only ASes present in the Internet Routing Table:	224
Average AS path length visible in the Internet Routing Table:	4.3
Max AS path length visible:	54
Max AS path prepend of ASN (55644)	51
Prefixes from unregistered ASNs in the Routing Table:	60
Number of instances of unregistered ASNs:	64
Number of 32-bit ASNs allocated by the RIRs:	19374
Number of 32-bit ASNs visible in the Routing Table:	15044
Prefixes from 32-bit ASNs in the Routing Table:	61327
Number of bogon 32-bit ASNs visible in the Routing Table:	63
Special use prefixes present in the Routing Table:	0
Prefixes being announced from unallocated address space:	349
Number of addresses announced to Internet:	2848245860
Equivalent to 169 /8s, 196 /16s and 200 /24s	
Percentage of available address space announced:	76.9
Percentage of allocated address space announced:	76.9
Percentage of available address space allocated:	100.0
Percentage of address space in use by end-sites:	98.7
Total number of prefixes smaller than registry allocations:	217721

APNIC Region

Prefixes being announced by APNIC Region ASes:	179318
Total APNIC prefixes after maximum aggregation:	51339
APNIC Deaggregation factor:	3.49
Prefixes being announced from the APNIC address blocks:	178368
Unique aggregates announced from the APNIC address blocks:	73892
APNIC Region origin ASes present in the Internet Routing Table:	8226
APNIC Prefixes per ASN:	21.68
APNIC Region origin ASes announcing only one prefix:	2311
APNIC Region transit ASes present in the Internet Routing Table:	1165
Average APNIC Region AS path length visible:	4.4
Max APNIC Region AS path length visible:	54
Number of APNIC region 32-bit ASNs visible in the Routing Table:	3067
Number of APNIC addresses announced to Internet:	763529572
Equivalent to 45 /8s, 130 /16s and 137 /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	5546	4190	74	ERX-CERNET-BKB China Education and
7545	3982	406	383	TPG-INTERNET-AP TPG Telecom Limite
22773	3817	2953	160	ASN-CXA-ALL-CCI-22773-RDC - Cox Co
10620	3532	543	205	Telmex Colombia S.A., CO
6327	3423	1333	83	SHAW - Shaw Communications Inc., C
39891	3388	190	24	ALJAWWALSTC-AS, SA
17974	2976	902	73	TELKOMNET-AS2-AP PT Telekomunikasi
8551	2974	377	40	BEZEQ-INTERNATIONAL-AS Bezeqint In
20940	2916	967	2098	AKAMAI-ASN1, US
4766	2809	11134	754	KIXS-AS-KR Korea Telecom, KR
9829	2745	1499	540	BSNL-NIB National Internet Backbon
8151	2510	3404	574	Uninet S.A. de C.V., MX
18566	2179	405	109	MEGAPATH5-US - MegaPath Corporatio
9808	2167	8699	32	CMNET-GD Guangdong Mobile Communic
4755	2090	423	223	TATACOMM-AS TATA Communications fo
11830	2090	369	57	Instituto Costarricense de Electri
6389	2064	3671	39	BELLSOUTH-NET-BLK - BellSouth.net
45899	2048	1424	111	VNPT-AS-VN VNPT Corp, VN
34984	2015	329	410	TELLCOM-AS, TR
20115	2011	2172	418	CHARTER-NET-HKY-NC - Charter Commu

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	/8:15	/9:13	/10:36	/11:104	/12:280
/13:545	/14:1047	/15:1847	/16:13462	/17:7643	/18:13422
/19:24684	/20:38617	/21:41208	/22:77666	/23:64432	/24:366559
/25:864	/26:607	/27:641	/28:34	/29:21	/30:18
/31:2	/32:26				

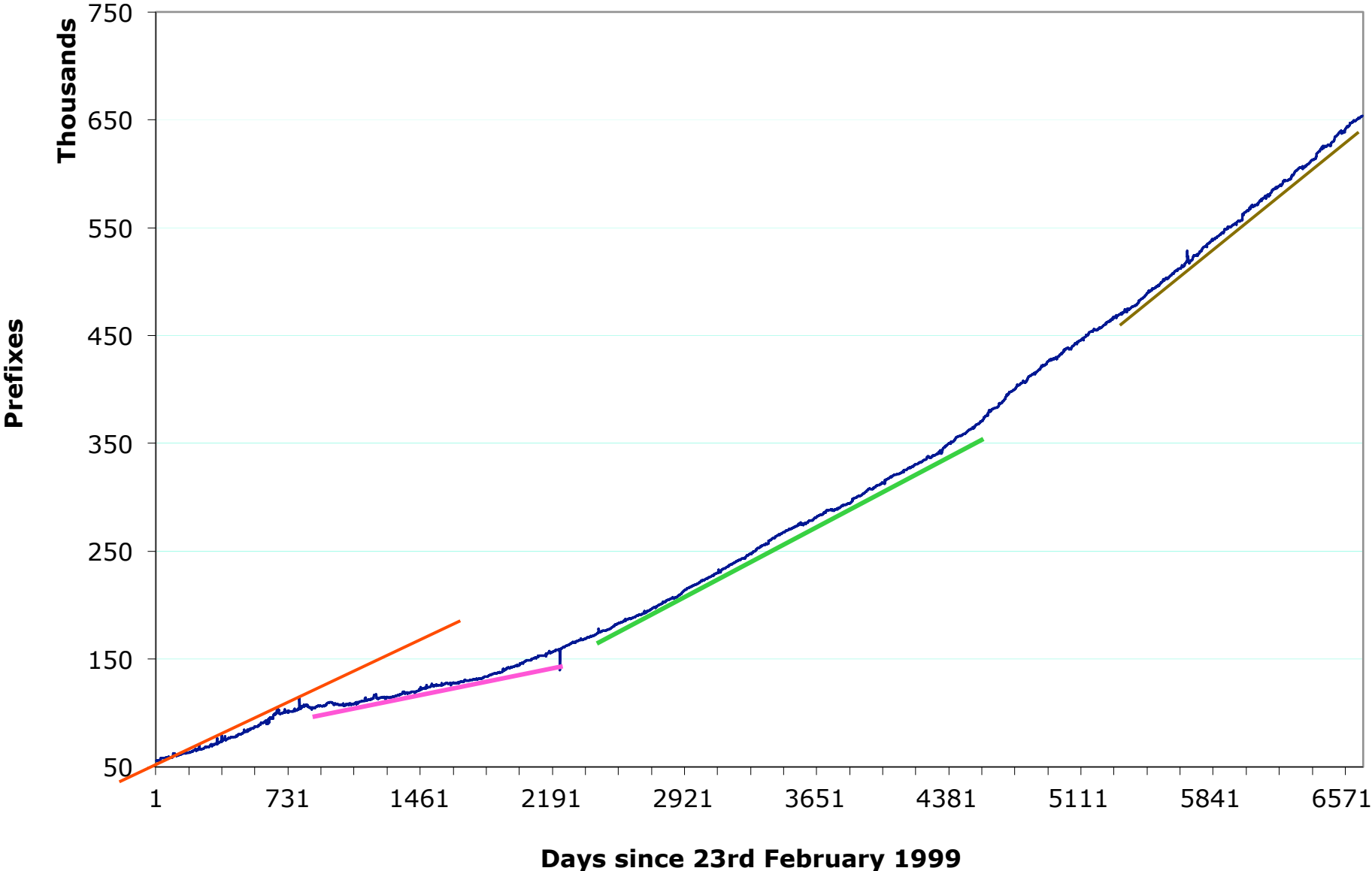
July 2017 ↑

July 2016 ↓

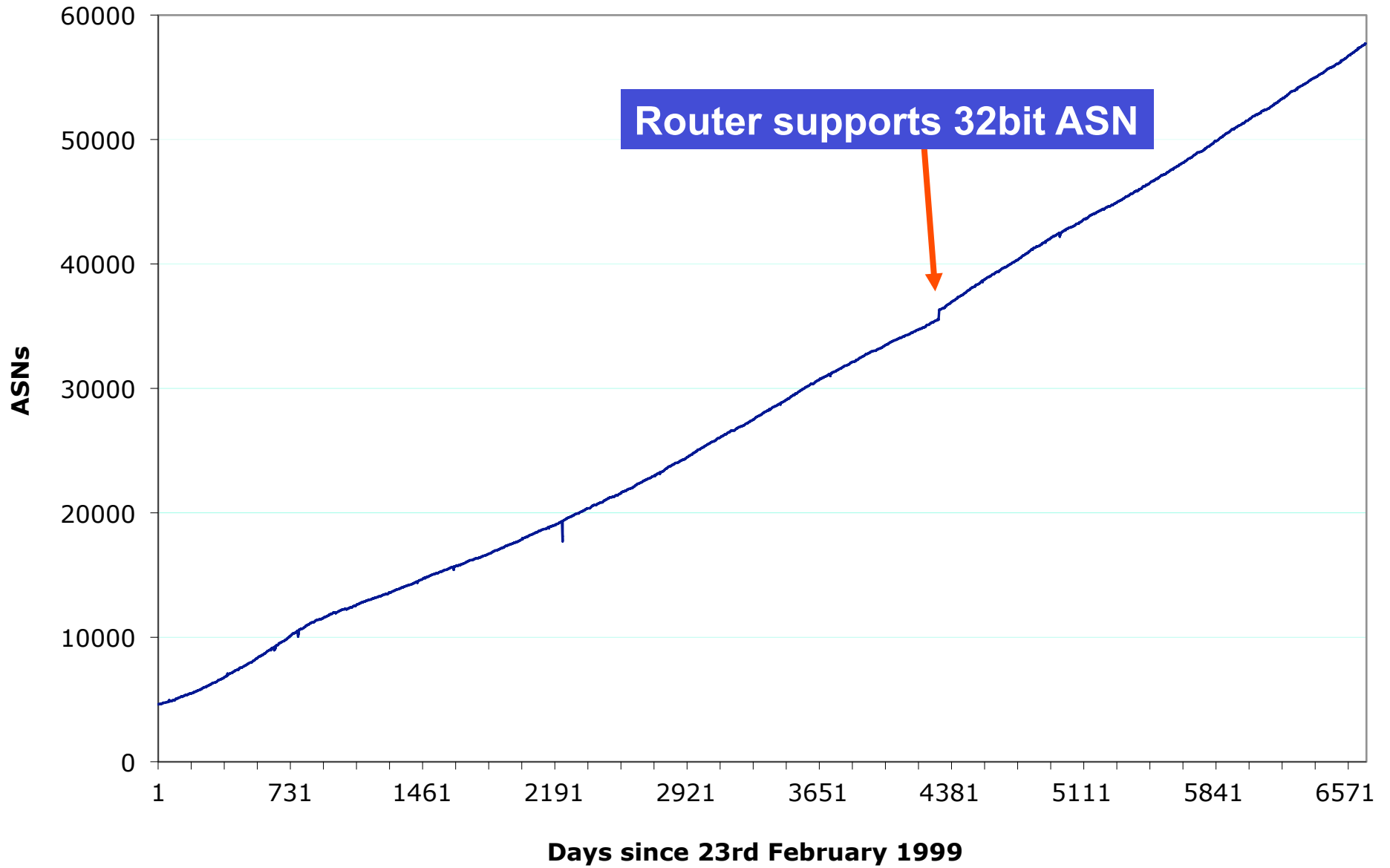
Number of prefixes announced by prefix length

/1:0	/2:0	/3:0	/4:0	/5:0	/6:0
/7:0	/8:16	/9:13	/10:36	/11:100	/12:266
/13:515	/14:1036	/15:1768	/16:13160	/17:7791	/18:12747
/19:25306	/20:38233	/21:40074	/22:66790	/23:58240	/24:335655
/25:565	/26:585	/27:375	/28:49	/29:32	/30:16
/31:1	/32:31				

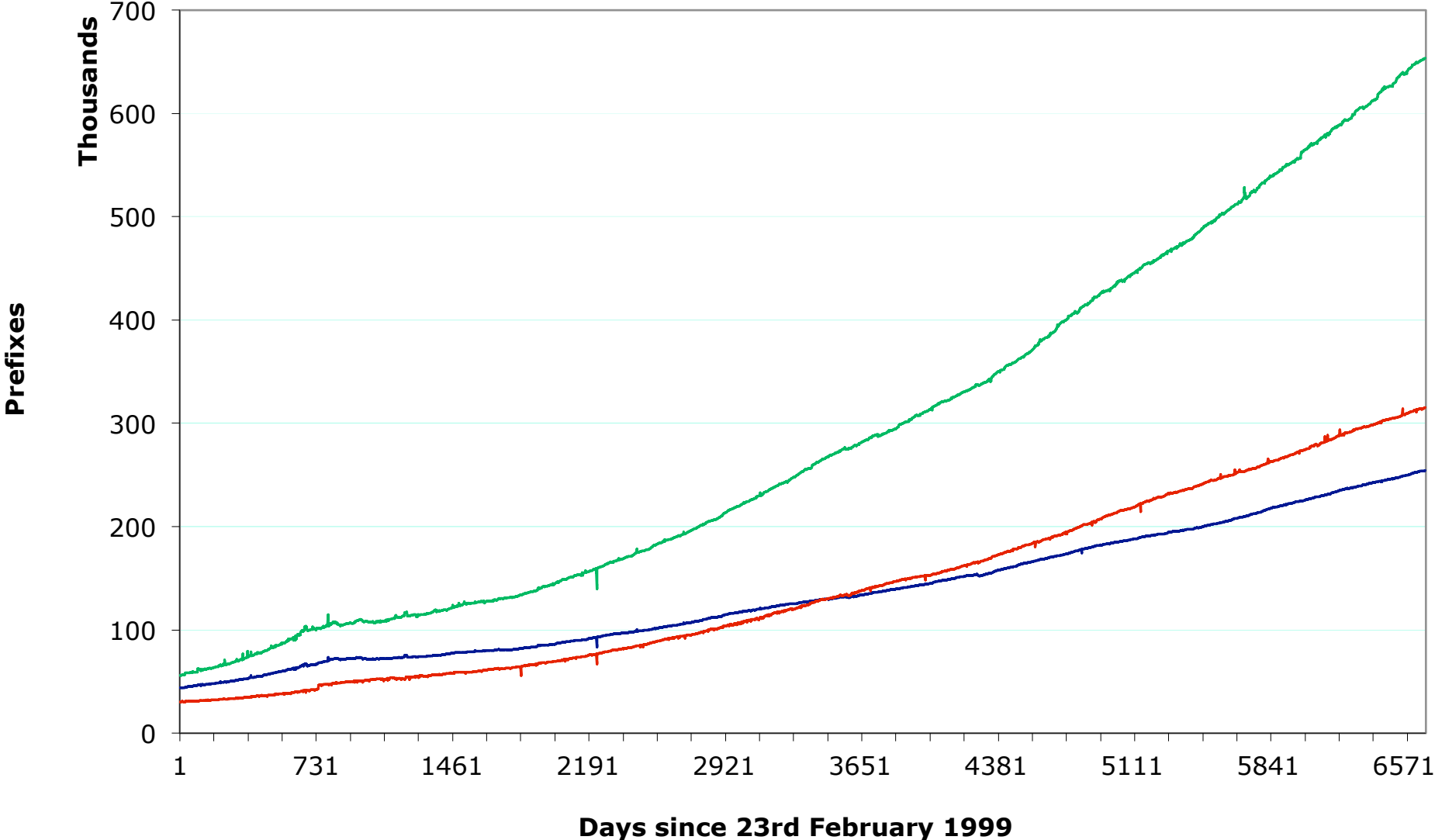
Global IPv4 Routing Table



AS Growth

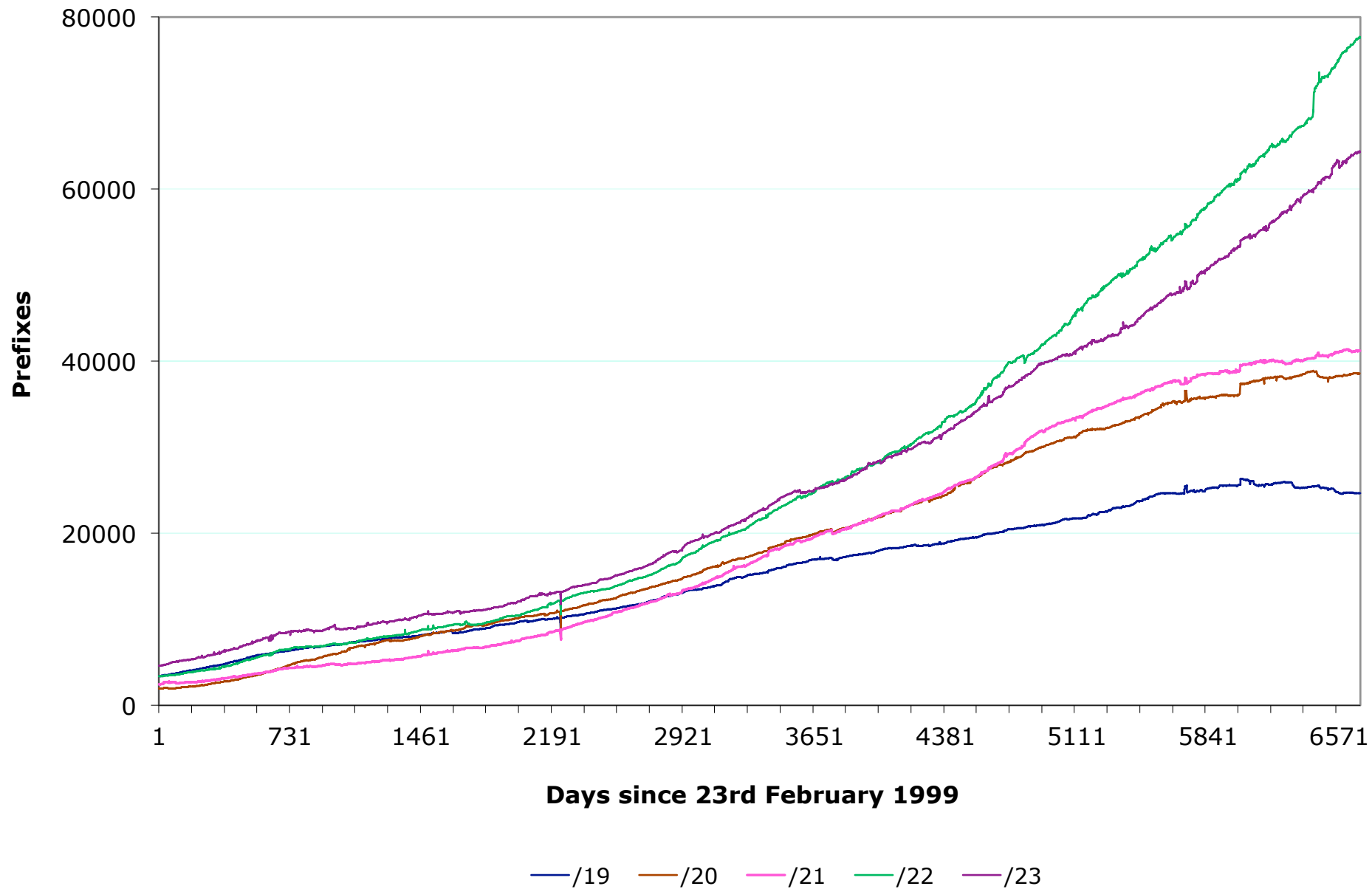


Max Aggregation vs Unique Prefixes

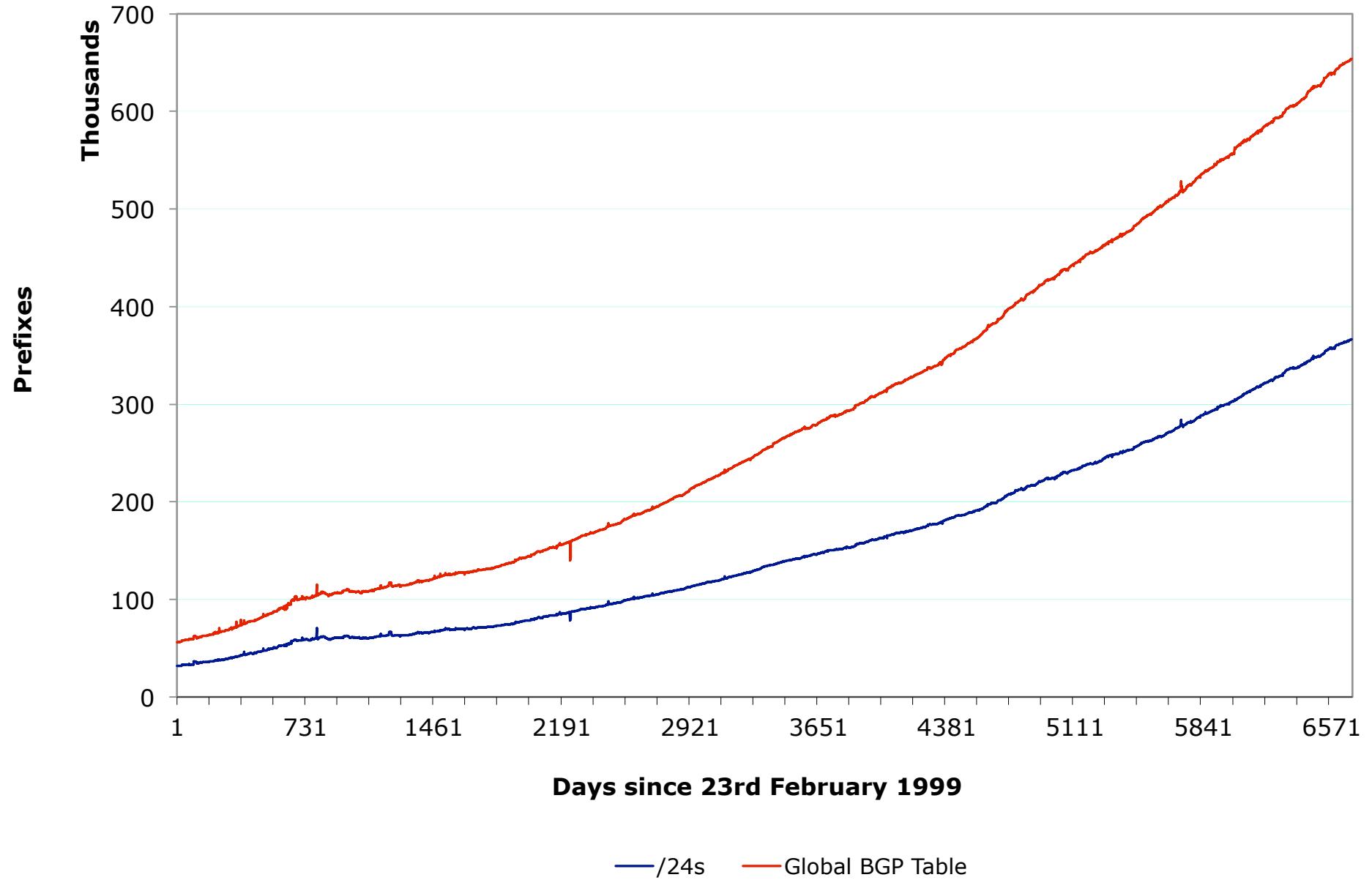


— Max Aggregation — Unique Prefixes — Global BGP Table

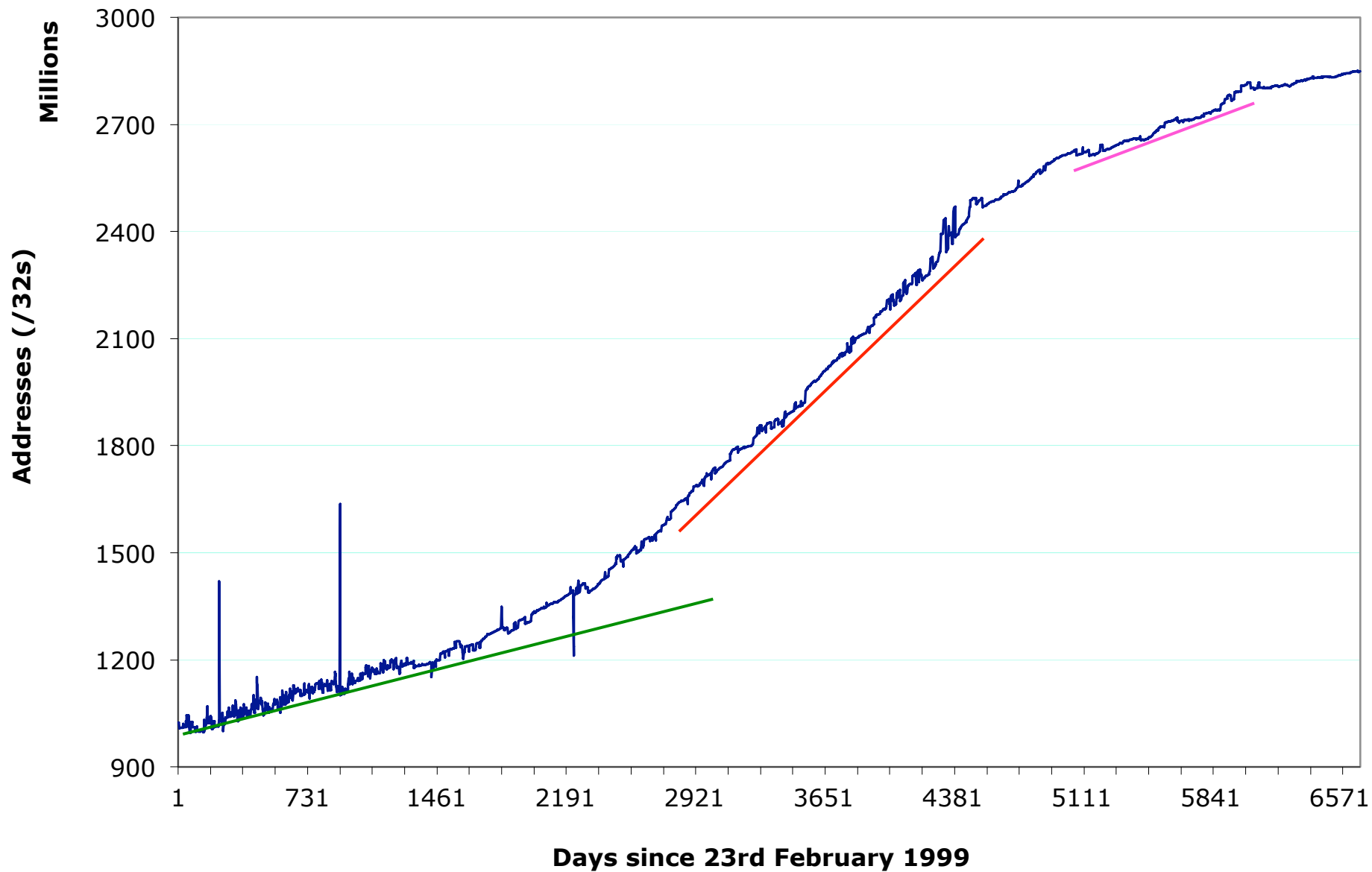
Prefix sizes announced



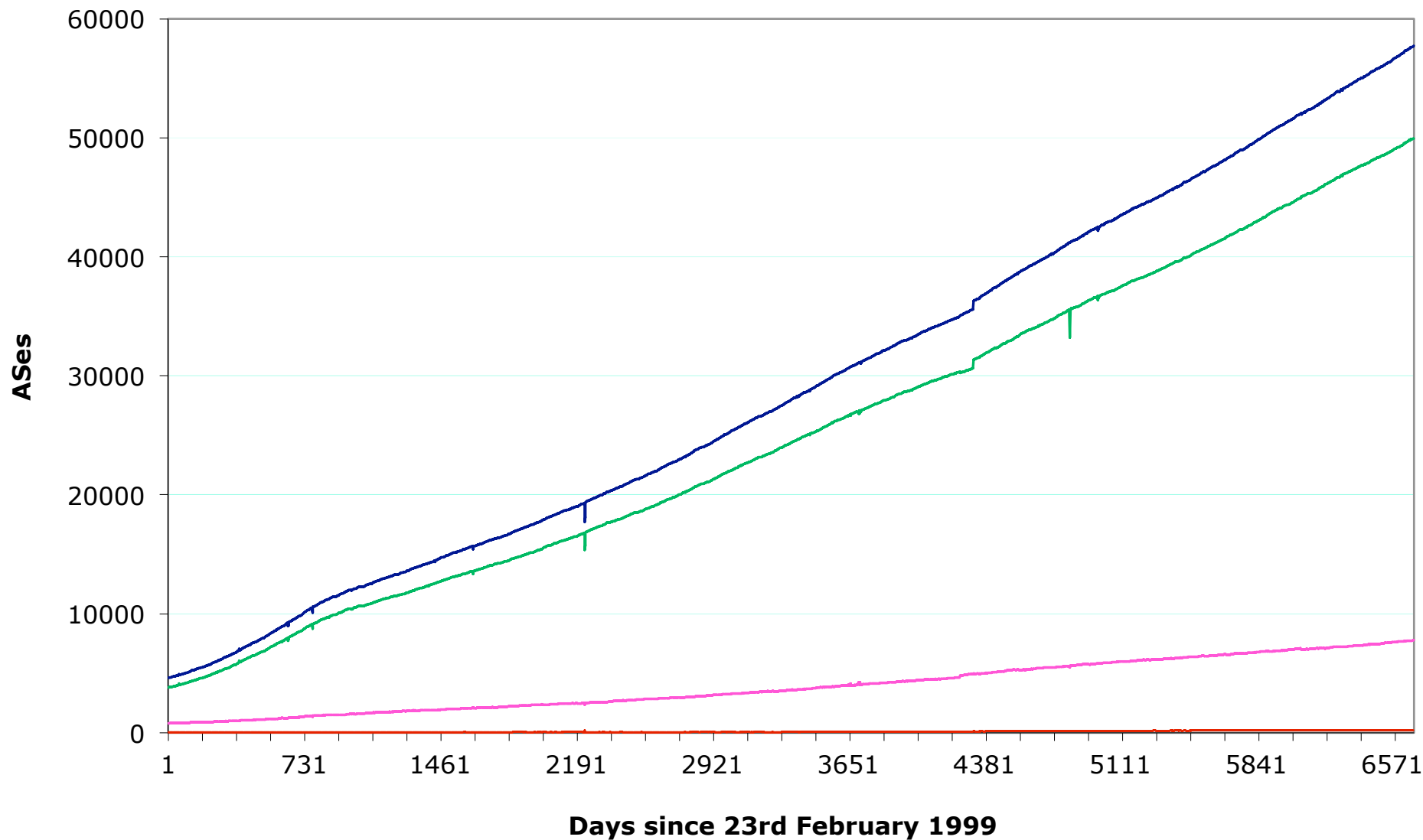
/24s announced



Address Space announced



AS Announcements



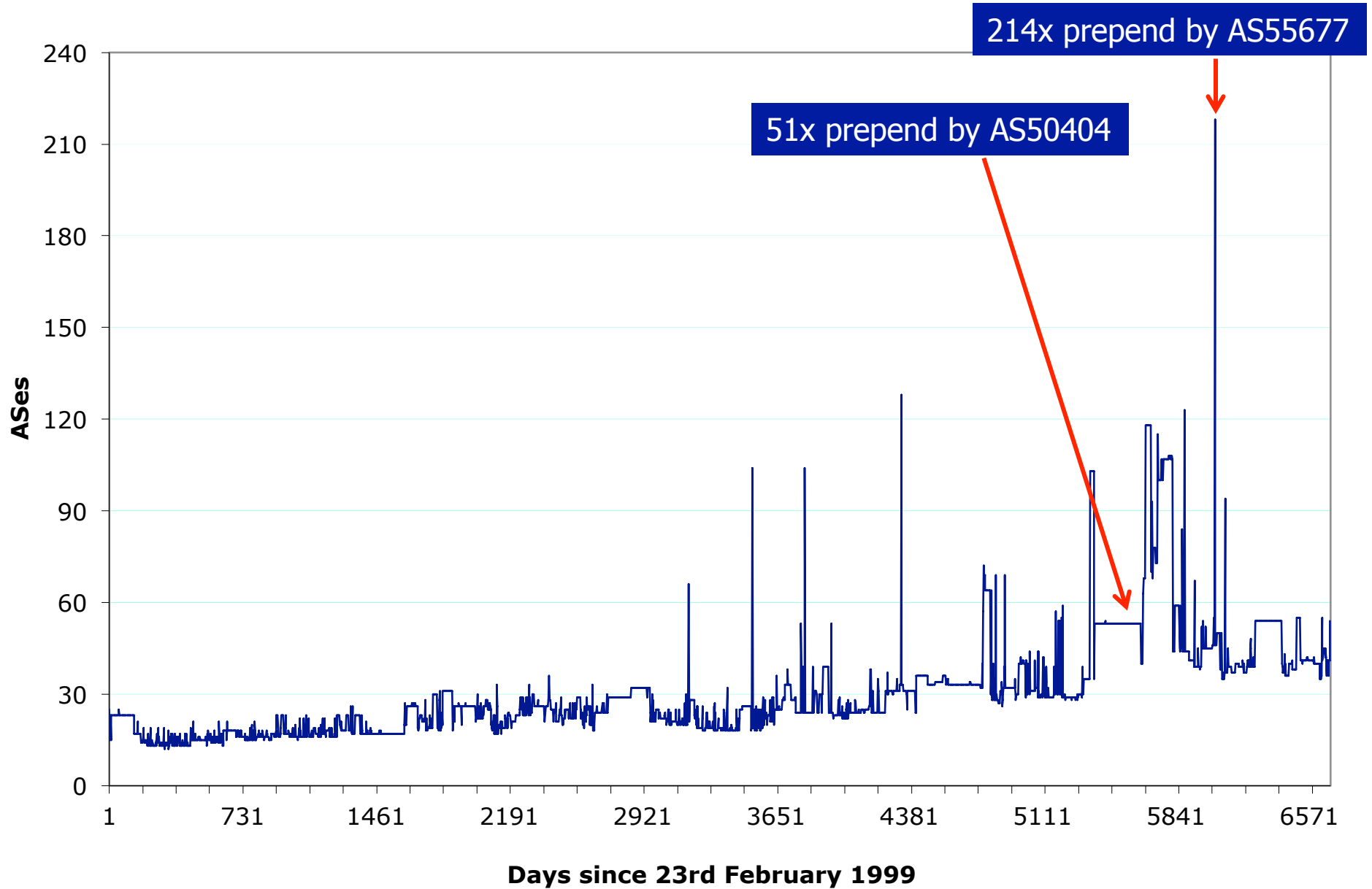
— Total ASNs

— Origin-only ASNs

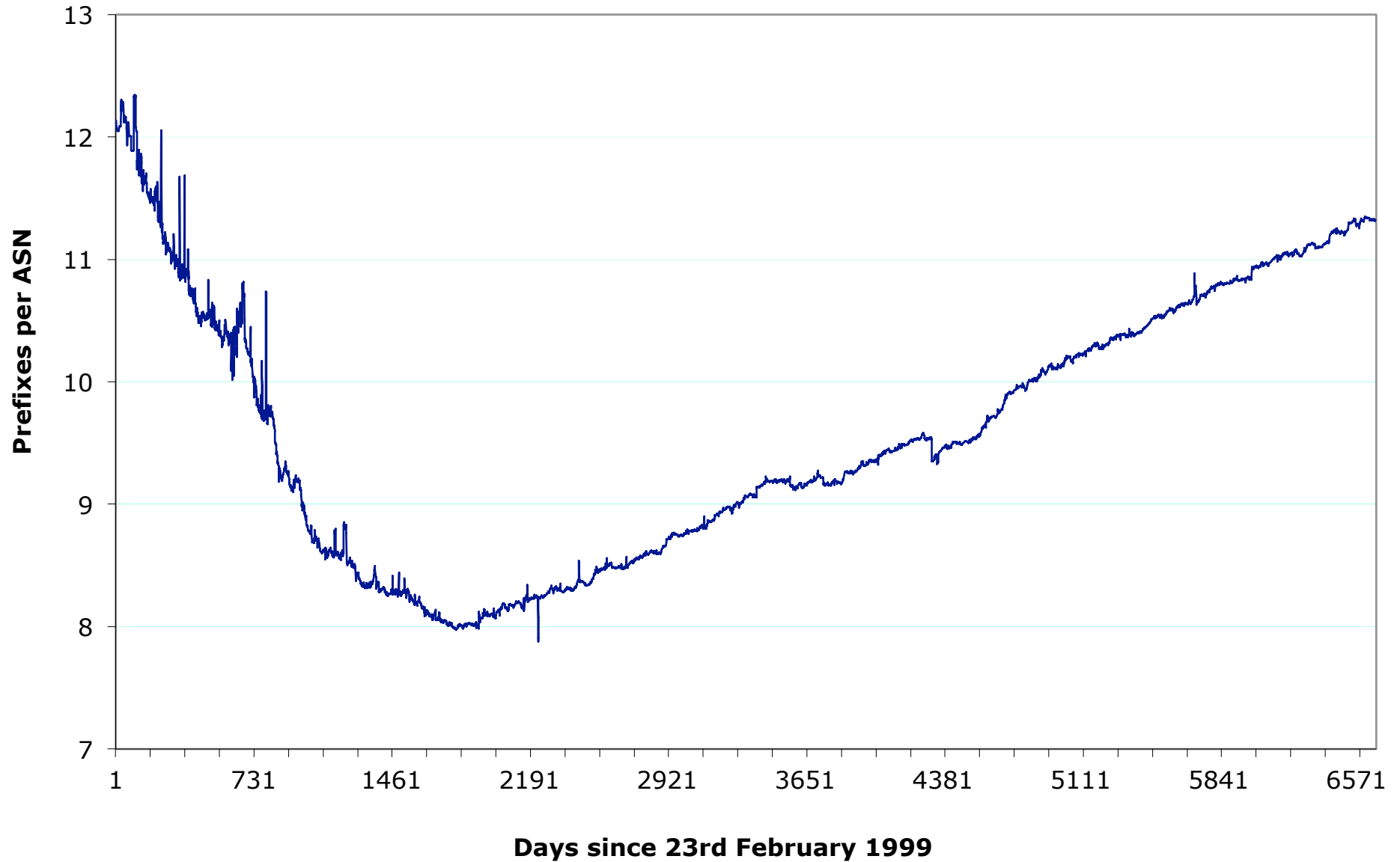
— ASN providing Transit & Origin

— 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”



July 2017

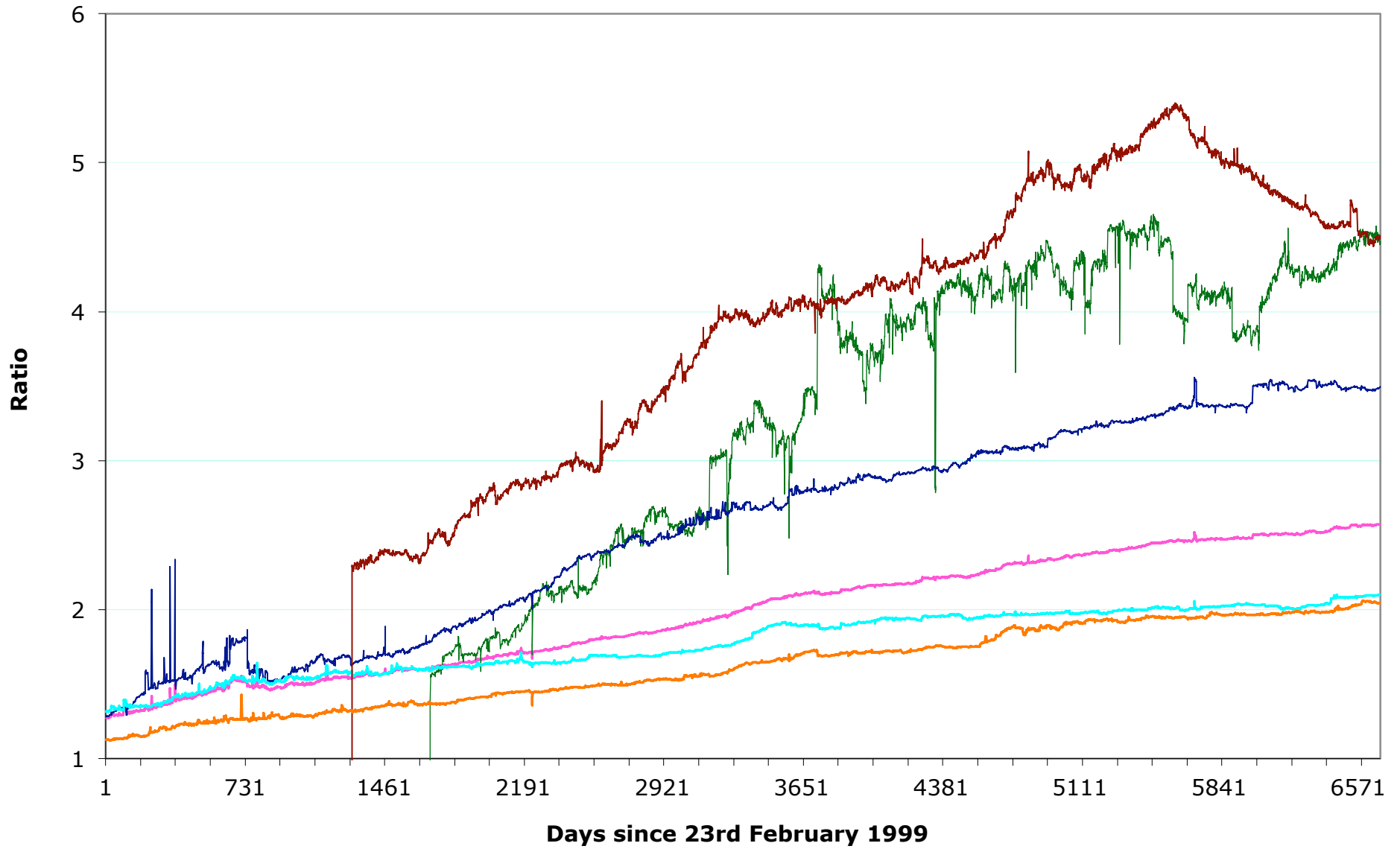
Total Prefixes

- Global BGP Table
 - 654k prefixes
- Europe & Middle East
 - 175k prefixes
- North America
 - 199k prefixes
- Asia & Pacific
 - 179k prefixes
- Africa
 - 17k prefixes
- Latin America & Caribbean
 - 83k prefixes

Deaggregation Factor

- Global Average
 - 2.57
- Europe & Middle East
 - 2.04
- North America
 - 2.10
- Asia & Pacific
 - 3.49
- Africa
 - 4.47
- Latin America & Caribbean
 - 4.51

Deaggregation: RIR Regions vs Global



— Global — AfriNIC — APNIC — ARIN — LACNIC — RIPE

Asia Pacific Aggregation Savings Summary

ASN	No of Nets	Savings	Description
7545	3982	3599	TPG-INTERNET-AP TPG Telecom Limited, AU
17974	2976	2903	TELKOMNET-AS2-AP PT Telekomunikasi Indone
9829	2745	2205	BSNL-NIB National Internet Backbone, IN
9808	2167	2135	CMNET-GD Guangdong Mobile Communication C
4766	2809	2055	KIXS-AS-KR Korea Telecom, KR
45899	2048	1937	VNPT-AS-VN VNPT Corp, VN
4755	2090	1867	TATACOMM-AS TATA Communications formerly
7552	1642	1569	VIETEL-AS-AP Viettel Corporation, VN
9498	1598	1457	BBIL-AP BHARTI Airtel Ltd., IN
45090	1397	1377	CNNIC-TENCENT-NET-AP Shenzhen Tencent Com
17488	1566	1294	HATHWAY-NET-AP Hathway IP Over Cable Inte
24560	1471	1204	AIRTELBROADBAND-AS-AP Bharti Airtel Ltd.,
55430	1183	1151	STARHUBINTERNET-AS-NGNBN Starhub Internet
4808	1544	1101	CHINA169-BJ China Unicom Beijing Province
56040	1109	1072	CMNET-GUANGDONG-AP China Mobile communica
9583	1579	1037	SIFY-AS-IN Sify Limited, IN
18403	1047	1024	FPT-AS-AP The Corporation for Financing &
23969	1457	853	TOT-NET TOT Public Company Limited, TH
45528	980	818	TDN Tikona Digital Networks Pvt Ltd., IN
18101	940	785	RELIANCE-COMMUNICATIONS-IN Reliance Commu

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

India Aggregation Savings Summary

ASN	No of Nets	Savings	Description
9829	2745	2205	BSNL-NIB National Internet Backbone, IN
4755	2090	1867	TATACOMM-AS TATA Communications formerly
9498	1598	1457	BBIL-AP BHARTI Airtel Ltd., IN
17488	1566	1294	HATHWAY-NET-AP Hathway IP Over Cable Inte
24560	1471	1204	AIRTELROADBAND-AS-AP Bharti Airtel Ltd.,
9583	1579	1037	SIFY-AS-IN Sify Limited, IN
45528	980	818	TDN Tikona Digital Networks Pvt Ltd., IN
18101	940	785	RELIANCE-COMMUNICATIONS-IN Reliance Commu
45609	939	761	BHARTI-MOBILITY-AS-AP Bharti Airtel Ltd.
17762	538	515	HTIL-TTML-IN-AP Tata Teleservices Maharas
45271	571	512	ICLNET-AS-AP Idea Cellular Limited, IN
10201	494	485	DWL-AS-IN Dishnet Wireless Limited. Broad
17803	670	472	BSES-AS-AP BSES TeleCom Limited, IN
17439	517	451	NETMAGIC-AP Netmagic Datacenter Mumbai, I
10029	436	416	CITYCOMNETWORKS-AS CITYCOM NETWORKS PVT L
17908	497	404	TCISL Tata Communications, IN
18207	523	378	YOU-INDIA-AP YOU Broadband & Cable India
45820	401	329	TTSL-MEISISIP Tata Teleservices ISP AS, IN
45769	417	310	DVOIS-IN D-Vois Broadband Pvt Ltd, IN
45514	307	285	TELEMEDIA-SMB-AS-AP Bharti Airtel Ltd., T



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 09 July 2017 06:33 (UTC+1000)

50 Most active ASes for the past 7 days

RANK	ASN	UPDs	%	Prefixes	UPDs/Prefix	AS NAME
1	12389	123458	2.50%	1547	79.80	ROSTELECOM-AS, RU
2	9829	118667	2.40%	2752	43.12	BSNL-NIB National Internet Backbone, IN
3	8151	100676	2.04%	2521	39.93	Uninet S.A. de C.V., MX
4	3551	77920	1.58%	246	316.75	Universidad Tecnologica de Panama, PA
5	45899	65688	1.33%	2093	31.38	VNPT-AS-VN VNPT Corp, VN
6	23650	57904	1.17%	565	102.48	CHINANET-JS-AS-AP AS Number for CHINANET jiangsu province backbone, CN
7	11664	53619	1.08%	874	61.35	Techtel LMDS Comunicaciones Interactivas S.A., AR
8	17974	51470	1.04%	2977	17.29	TELKOMNET-AS2-AP PT Telekomunikasi Indonesia, ID
9	45514	41300	0.84%	307	134.53	TELEMEDIA-SMB-AS-AP Bharti Airtel Ltd., TELEMEDIA Services, for SMB customers, IN
10	9198	39906	0.81%	1040	38.37	KAZTELECOM-AS, KZ
11	4134	35956	0.73%	860	41.81	CHINANET-BACKBONE No.31,Jin-rong Street, CN
12	262493	29147	0.59%	36	809.64	Global Tech Internet Banda Larga EPP - Ltda, BR
13	8048	28852	0.58%	383	75.33	CANTV Servicios, Venezuela, VE
14	22059	27980	0.57%	7	3997.14	-Reserved AS-, ZZ
15	13118	27686	0.56%	98	282.51	ASN-YARTELECOM PJSC Rostelecom, RU
16	3832	26943	0.55%	20	1347.15	CINE-NET - Cinenet Communications, US
17	16586	25793	0.52%	205	125.82	CLEARWIRE - CLEAR WIRELESS LLC, US
18	81	25696	0.52%	59	435.53	NCREN - MCNC, US
19	24955	25073	0.51%	679	36.93	UBN-AS, RU
20	327728	23598	0.48%	4	5899.50	CTV, TZ
21	39891	23065	0.47%	3388	6.81	ALJAWWALSTC-AS, SA
22	3203	21383	0.43%	2	10691.50	ASVIDEOKANAL, RU
23	28573	21293	0.43%	1248	17.06	CLARO S.A., BR
24	4755	20704	0.42%	2092	9.90	TATACOMM-AS TATA Communications formerly VSNL is Leading ISP, IN
25	266152	19795	0.40%	7	2827.86	PJM TELECOM, BR
26	12646	17722	0.36%	8	2215.25	ESOTEL-AS, RU
27	24560	17613	0.36%	1473	11.96	AIRTELBROADBAND-AS-AP Bharti Airtel Ltd., Telemidia Services, IN

50 Most active Prefixes for the past 7 days

RANK	PREFIX	UPDs	%	Origin AS -- AS NAME
1	93.181.192.0/19	23348	0.41%	13118 -- ASN-YARTELECOM PJSC Rostelecom, RU
2	193.0.132.0/22	21380	0.38%	3203 -- ASVIDEOKANAL, RU
3	186.12.248.0/22	17264	0.30%	11664 -- Techtel LMDS Comunicaciones Interactivas S.A., AR
4	186.182.80.0/24	17251	0.30%	11664 -- Techtel LMDS Comunicaciones Interactivas S.A., AR
5	192.147.30.0/24	16357	0.29%	81 -- NCREN - MCNC, US
6	64.34.125.0/24	14076	0.25%	22059 -- -Reserved AS-, ZZ
7	76.191.107.0/24	13889	0.25%	22059 -- -Reserved AS-, ZZ
8	199.245.187.0/24	13782	0.24%	3832 -- CINE-NET - Cinenet Communications, US
9	198.148.151.0/24	13107	0.23%	3832 -- CINE-NET - Cinenet Communications, US
10	170.51.243.0/24	12610	0.22%	11664 -- Techtel LMDS Comunicaciones Interactivas S.A., AR 19037 -- AMX Argentina S.A., AR
11	91.192.240.0/22	11878	0.21%	31560 -- INSOURCE, UA
12	154.72.20.0/24	11795	0.21%	327728 -- CTV, TZ
13	154.72.21.0/24	11795	0.21%	327728 -- CTV, TZ
14	41.76.88.0/21	11771	0.21%	37213 -- SPICE-NET-, TZ
15	196.250.232.0/21	10657	0.19%	37662 -- WIOCC-AS, MU
16	192.154.32.0/19	9041	0.16%	81 -- NCREN - MCNC, US
17	202.56.215.0/24	8591	0.15%	24560 -- AIRTELBROADBAND-AS-AP Bharti Airtel Ltd., Telemedia Services, IN
18	66.19.194.0/24	8214	0.14%	6316 -- AS-PAETEC-NET - PaeTec Communications, Inc., US
19	216.238.254.0/23	8142	0.14%	13904 -- COSLINK - Cherryland Services Inc, US
20	13.15.32.0/20	7676	0.14%	22390 -- XEROX-WB - XEROX CORPORATION, US
21	180.191.176.0/20	6921	0.12%	132199 -- GLOBE-MOBILE-5TH-GEN-AS Globe Telecom Inc., PH
22	45.6.36.0/23	6554	0.12%	266152 -- PJM TELECOM, BR
23	45.6.36.0/22	6551	0.12%	266152 -- PJM TELECOM, BR
24	45.6.38.0/23	6538	0.12%	266152 -- PJM TELECOM, BR
25	187.63.254.0/24	5433	0.10%	28170 -- Wal-Mart Brasil LTDA, BR
26	91.242.74.0/23	5168	0.09%	202931 -- VIC_GRUP_SRL, MD
27	185.180.100.0/22	4838	0.09%	207238 -- TVNET, MD
28	91.242.80.0/24	4758	0.08%	202722 -- TELENET, MD
29	38.109.162.0/24	4524	0.08%	30507 -- GLWIZ - Gold Line Telemanagement, Inc., CA
30	186.182.234.0/24	4449	0.08%	11664 -- Techtel LMDS Comunicaciones Interactivas S.A., AR 19037 -- AMX Argentina S.A., AR
31	91.235.169.0/24	4444	0.08%	61039 -- ZMZ, RU



Observations

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