

# Internet IPv4 Routing Table Analysis Update



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SANOG 25

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

# Routing Report 14 January 2015

BGP routing table entries examined:	526210
Prefixes after maximum aggregation (per Origin AS):	202120
Deaggregation factor:	2.60
Unique aggregates announced (without unneeded subnets):	257138
Total ASes present in the Internet Routing Table:	49066
Prefixes per ASN:	10.72
Origin-only ASes present in the Internet Routing Table:	36401
Origin ASes announcing only one prefix:	16306
Transit ASes present in the Internet Routing Table:	6205
Transit-only ASes present in the Internet Routing Table:	169
Average AS path length visible in the Internet Routing Table:	4.5
Max AS path length visible:	107
Max AS path prepend of ASN ( 55644)	100
Prefixes from unregistered ASNs in the Routing Table:	1624
Unregistered ASNs in the Routing Table:	420
Number of 32-bit ASNs allocated by the RIRs:	8340
Number of 32-bit ASNs visible in the Routing Table:	6460
Prefixes from 32-bit ASNs in the Routing Table:	23278
Number of bogon 32-bit ASNs visible in the Routing Table:	11
Special use prefixes present in the Routing Table:	0
Prefixes being announced from unallocated address space:	397
Number of addresses announced to Internet:	2719679108
Equivalent to 162 /8s, 27 /16s and 2 /24s	
Percentage of available address space announced:	73.5
Percentage of allocated address space announced:	73.5
Percentage of available address space allocated:	100.0
Percentage of address space in use by end-sites:	97.1
Total number of prefixes smaller than registry allocations:	177096

## APNIC Region

Prefixes being announced by APNIC Region ASes:	130453
Total APNIC prefixes after maximum aggregation:	37953
APNIC Deaggregation factor:	3.44
Prefixes being announced from the APNIC address blocks:	135418
Unique aggregates announced from the APNIC address blocks:	55207
APNIC Region origin ASes present in the Internet Routing Table:	5010
APNIC Prefixes per ASN:	27.03
APNIC Region origin ASes announcing only one prefix:	1216
APNIC Region transit ASes present in the Internet Routing Table:	861
Average APNIC Region AS path length visible:	4.6
Max APNIC Region AS path length visible:	107
Number of APNIC region 32-bit ASNs visible in the Routing Table:	1247
Number of APNIC addresses announced to Internet:	740985472
Equivalent to 44 /8s, 42 /16s and 138 /24s	
Percentage of available APNIC address space announced:	86.6

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, 131072-135580

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 prefix count summary

ASN	No of nets	/20 equiv	Max Agg	Description
10620	3057	495	248	Telmex Colombia S.A.
22773	2931	2955	141	Cox Communications Inc.
4766	2912	11556	910	Korea Telecom
6389	2891	3688	51	BellSouth.net Inc.
17974	2827	904	77	PT Telekomunikasi Indonesia
3356	2562	10684	473	Level 3 Communications, Inc.
7545	2495	336	128	TPG Telecom Limited
28573	2315	2126	118	NET Serviços de Comunicação
18566	2042	379	183	MegaPath Corporation
4755	1933	418	191	TATA Communications formerly
34984	1933	300	359	TELLCOM ILETISIM HIZMETLERI A
20115	1854	1825	450	Charter Communications
6147	1786	374	30	Telefonica del Peru S.A.A.
7303	1768	1172	237	Telecom Argentina S.A.
4538	1757	4190	71	China Education and Research
9829	1675	1323	28	National Internet Backbone
6983	1629	867	245	EarthLink, Inc.
4323	1622	1037	408	tw telecom holdings, inc.
20940	1551	606	1149	Akamai International B.V.
9808	1523	6719	19	Guangdong Mobile Communicatio

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	/9:12	/10:31	/11:92	/12:265
/13:502	/14:998	/15:1724	/16:13049	/17:7194	/18:12031
/19:24907	/20:35645	/21:38191	/22:56730	/23:49309	/24:282556
/25:1146	/26:1083	/27:679	/28:17	/29:14	/30:10
/31:0	/32:9				

January 2015 ↑

January 2014 ↓

## Number of prefixes announced by prefix length

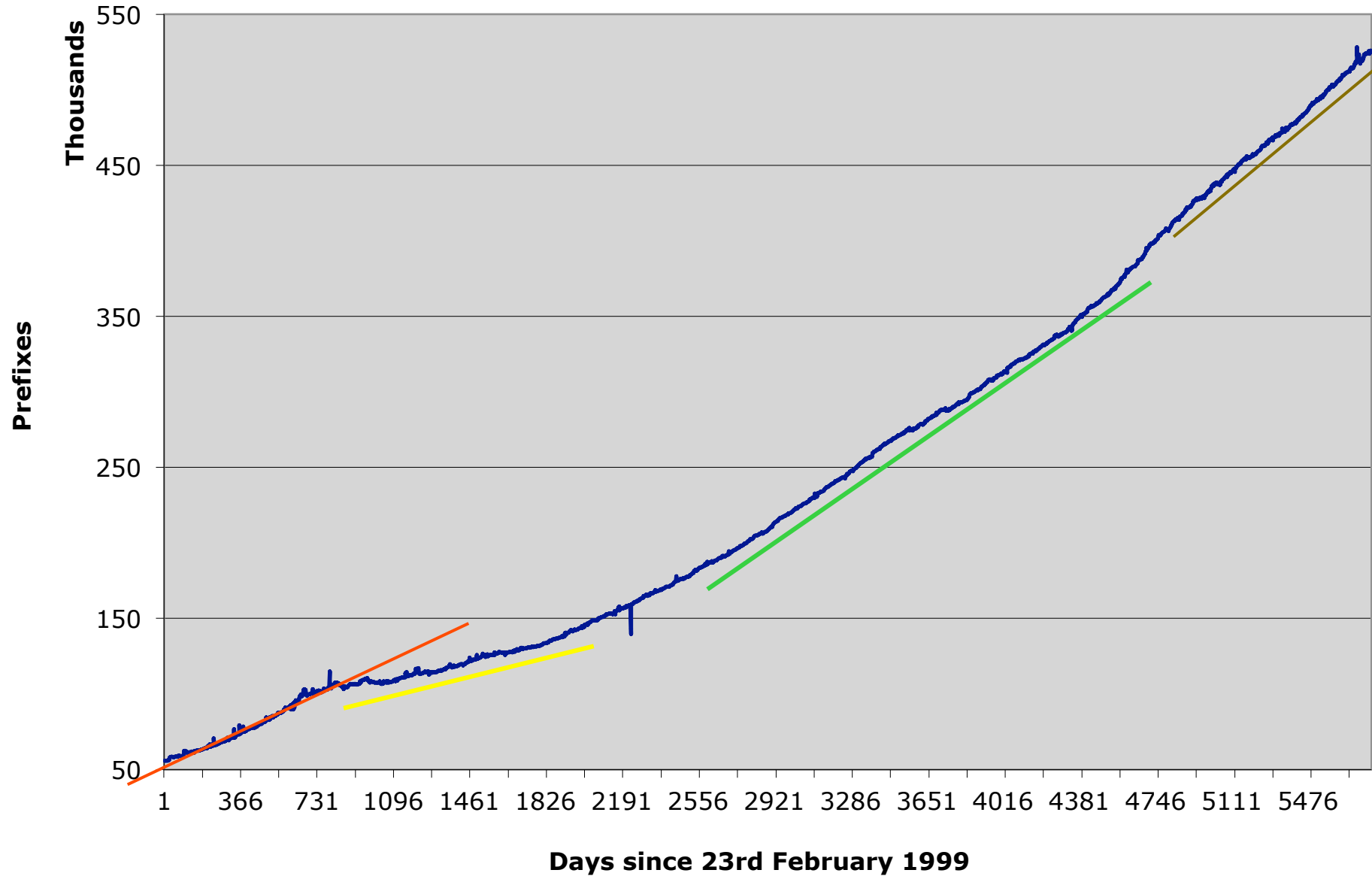
/1:0	/2:0	/3:0	/4:0	/5:0	/6:0
/7:0	/8:16	/9:11	/10:30	/11:92	/12:254
/13:475	/14:943	/15:1639	/16:12851	/17:6809	/18:11446
/19:23374	/20:33233	/21:35859	/22:50861	/23:44171	/24:253485
/25:787	/26:949	/27:432	/28:48	/29:72	/30:32
/31:0	/32:14				

## Prefixes Smaller than Registry Allocations

ASN	No of nets	Total ann.	Description
22773	2144	2931	Cox Communications Inc.
18566	1997	2042	MegaPath Corporation
6389	1671	2891	BellSouth.net Inc.
30036	1368	1523	Mediacom Communications Corp
6147	1329	1786	Telefonica del Peru S.A.A.
6983	1315	1629	EarthLink, Inc.
34984	1237	1933	TELLCOM ILETISIM HIZMETLERI A
11492	1124	1183	CABLE ONE, INC.
8402	1117	1453	OJSC "Vimpelcom"
10620	1092	3057	Telmex Colombia S.A.
22561	1017	1339	CenturyTel Internet Holdings,
31148	964	1045	Freenet Ltd.
13188	851	1037	TOV "Bank-Inform"
7011	834	1047	Frontier Communications of Am
8452	816	1493	TE-AS
13977	777	811	FAIRPOINT COMMUNICATIONS, INC
27738	759	781	Ecuadortelecom S.A.
3356	735	2562	Level 3 Communications, Inc.
4766	723	2912	Korea Telecom
6503	694	1227	Axtel, S.A.B. de C.V.

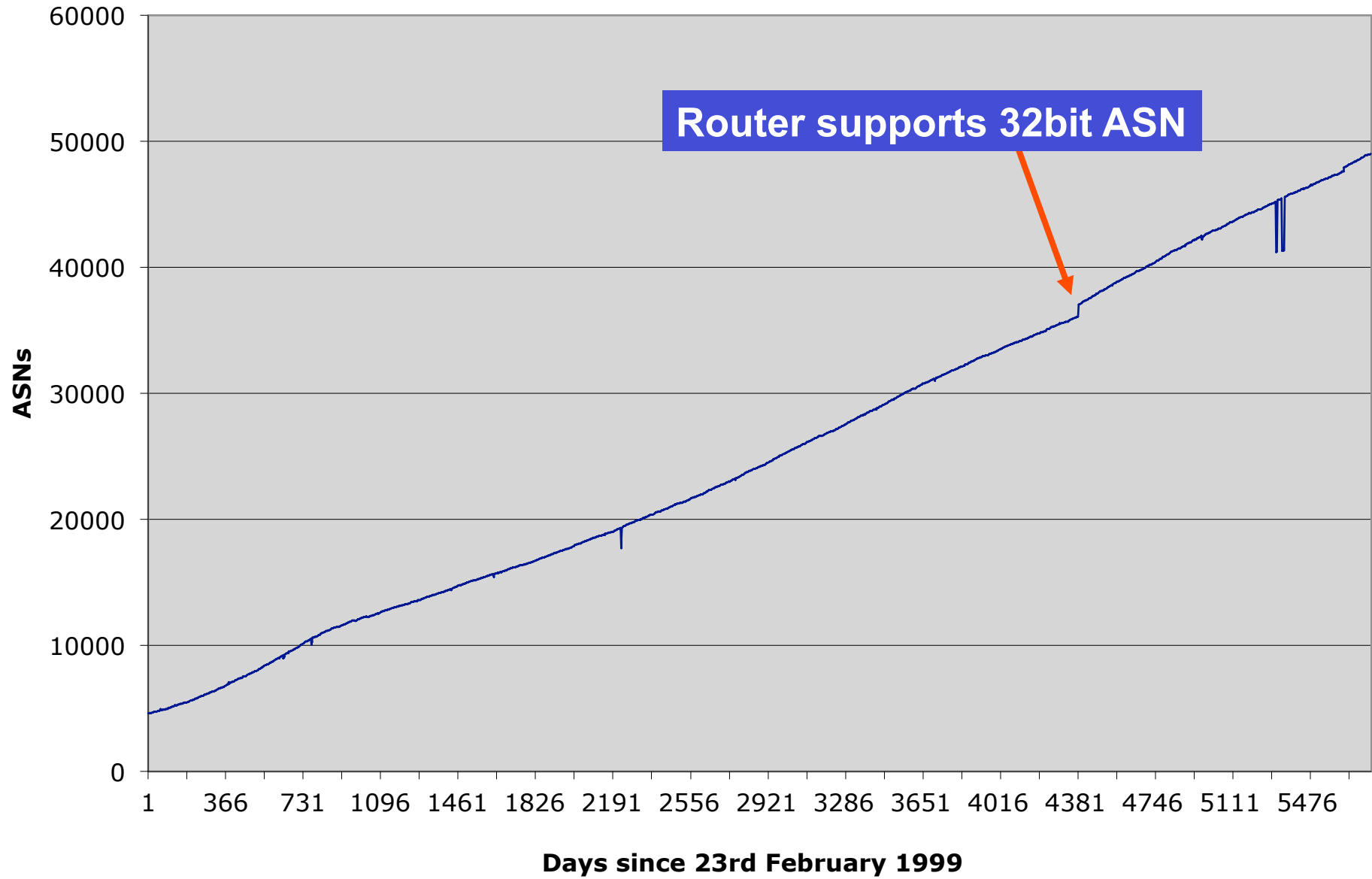
AfriNIC APNIC ARIN LACNIC RIPE NCC

# BGP Routing Table

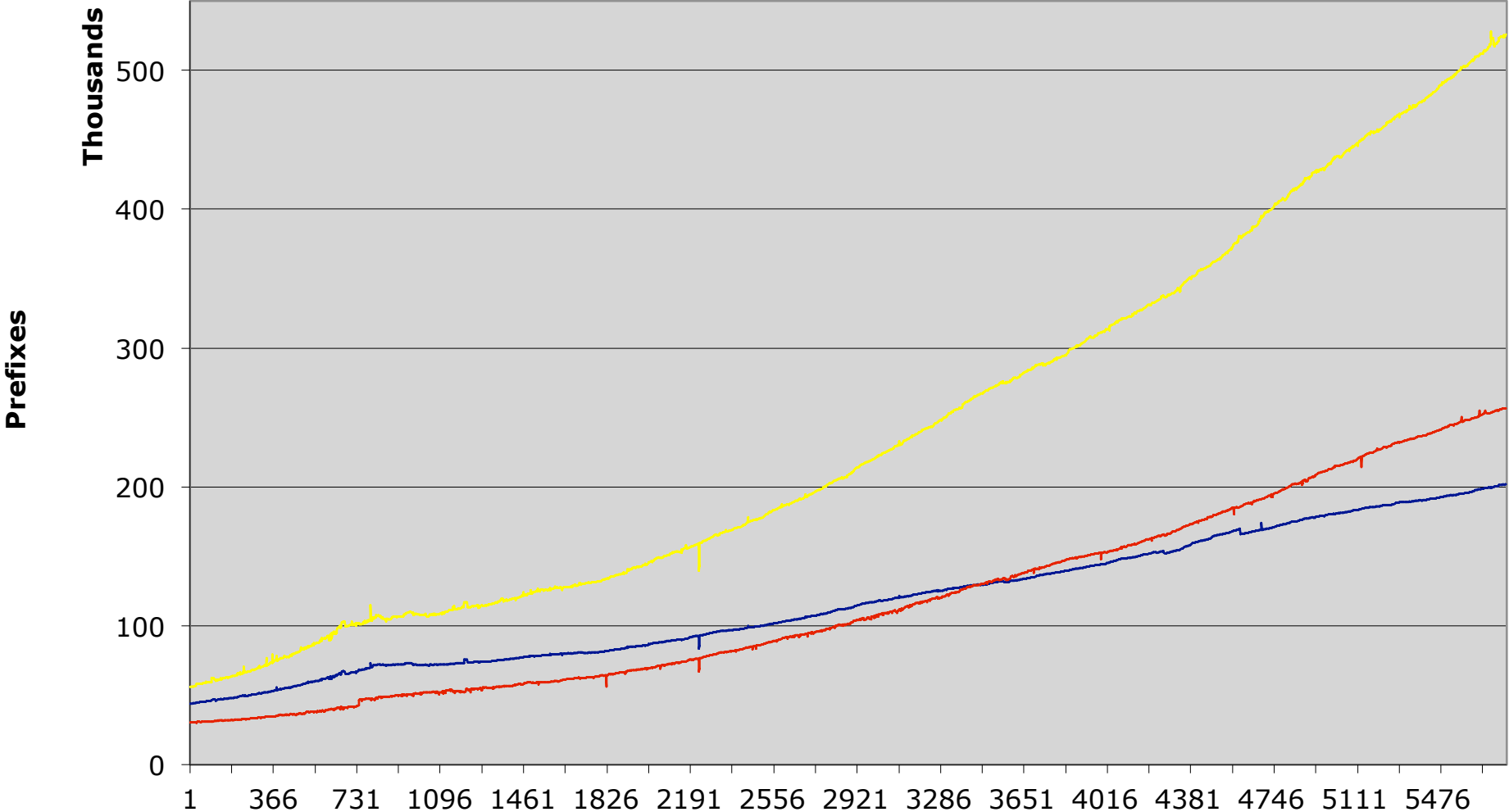




# AS Growth

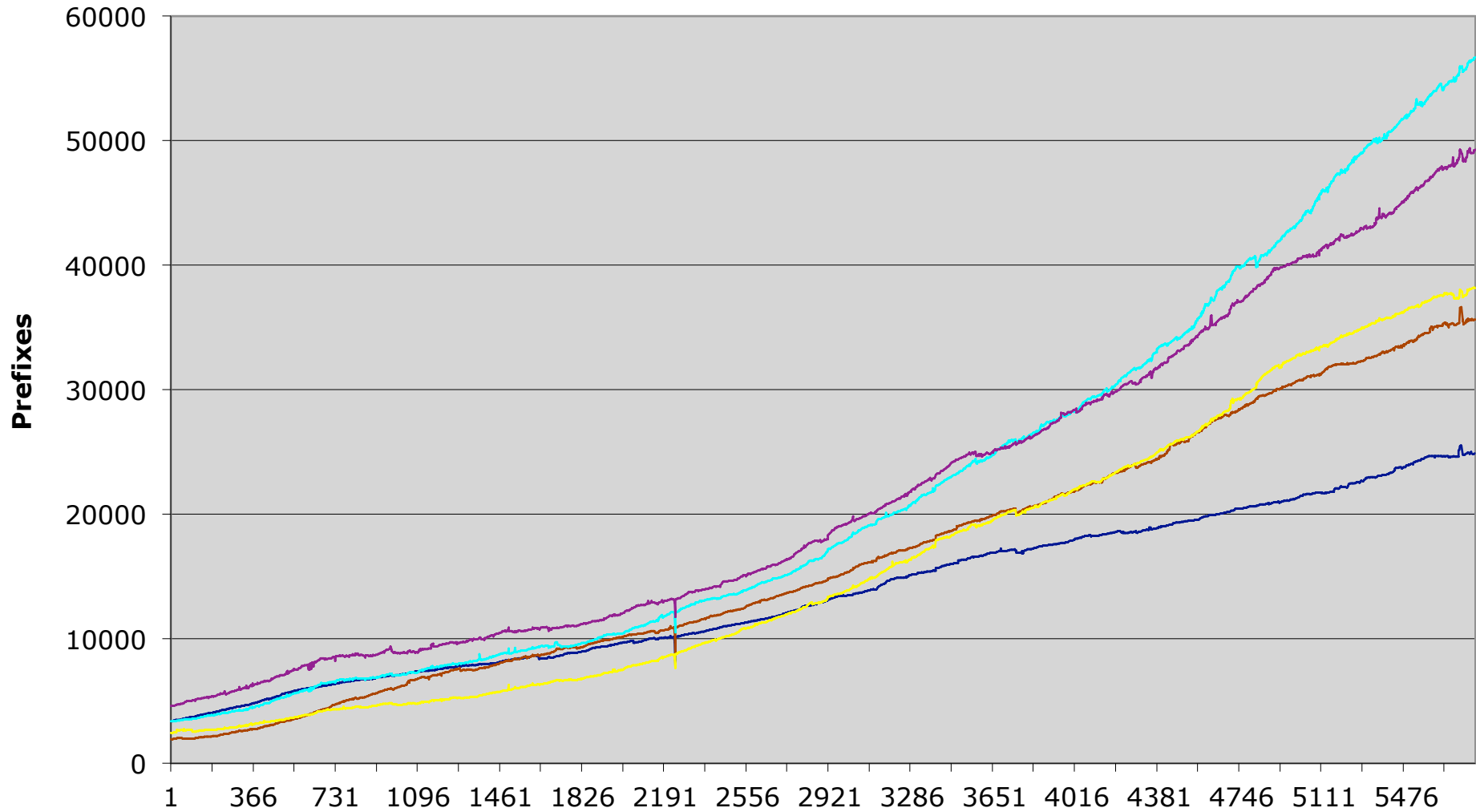


# Max Aggregation vs Unique Prefixes



— Max Aggregation    — Unique Prefixes    — Global BGP Table

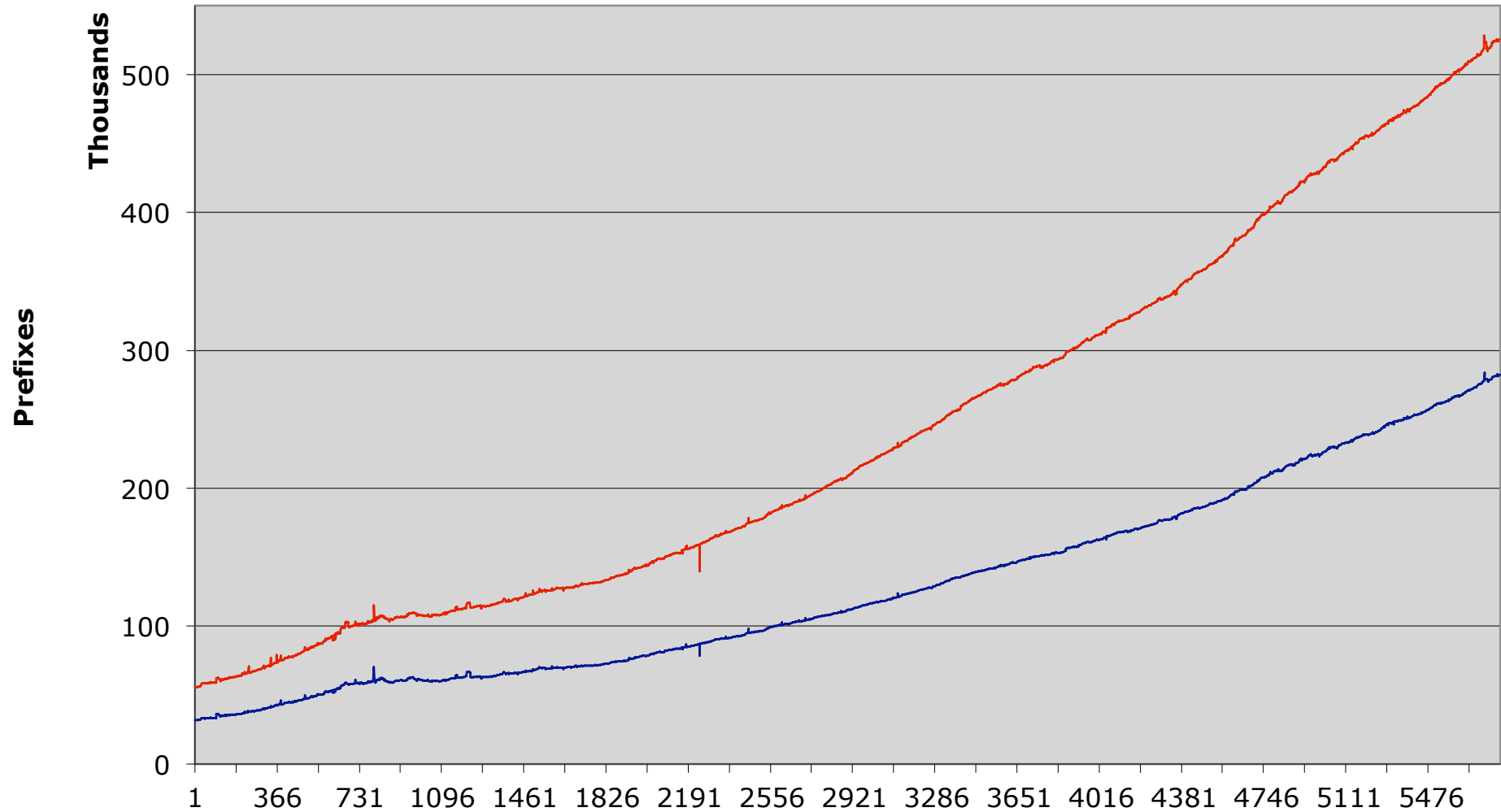
# Prefix sizes announced



Days since 23rd February 1999

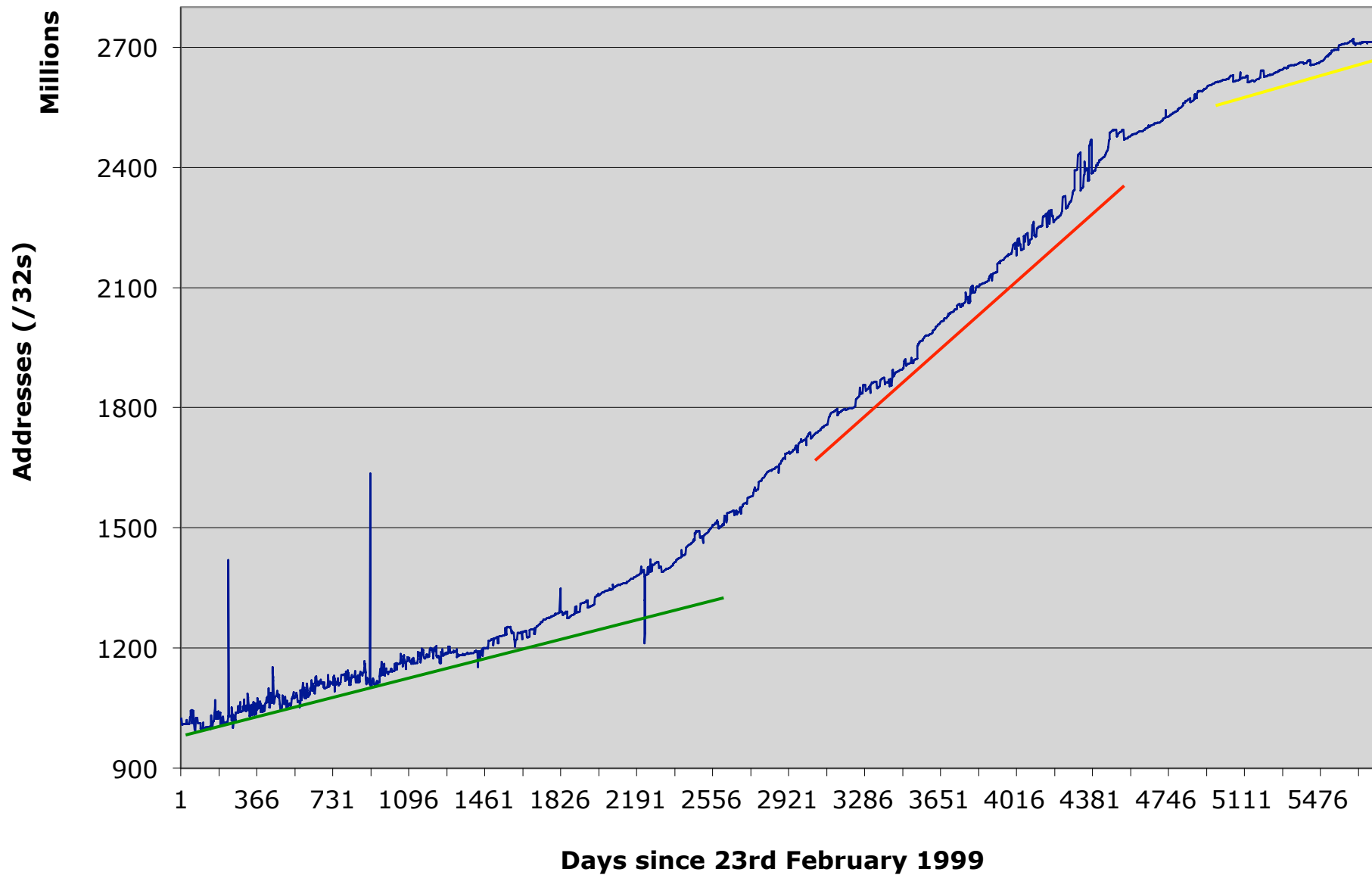
— /19 — /20 — /21 — /22 — /23

# /24s announced

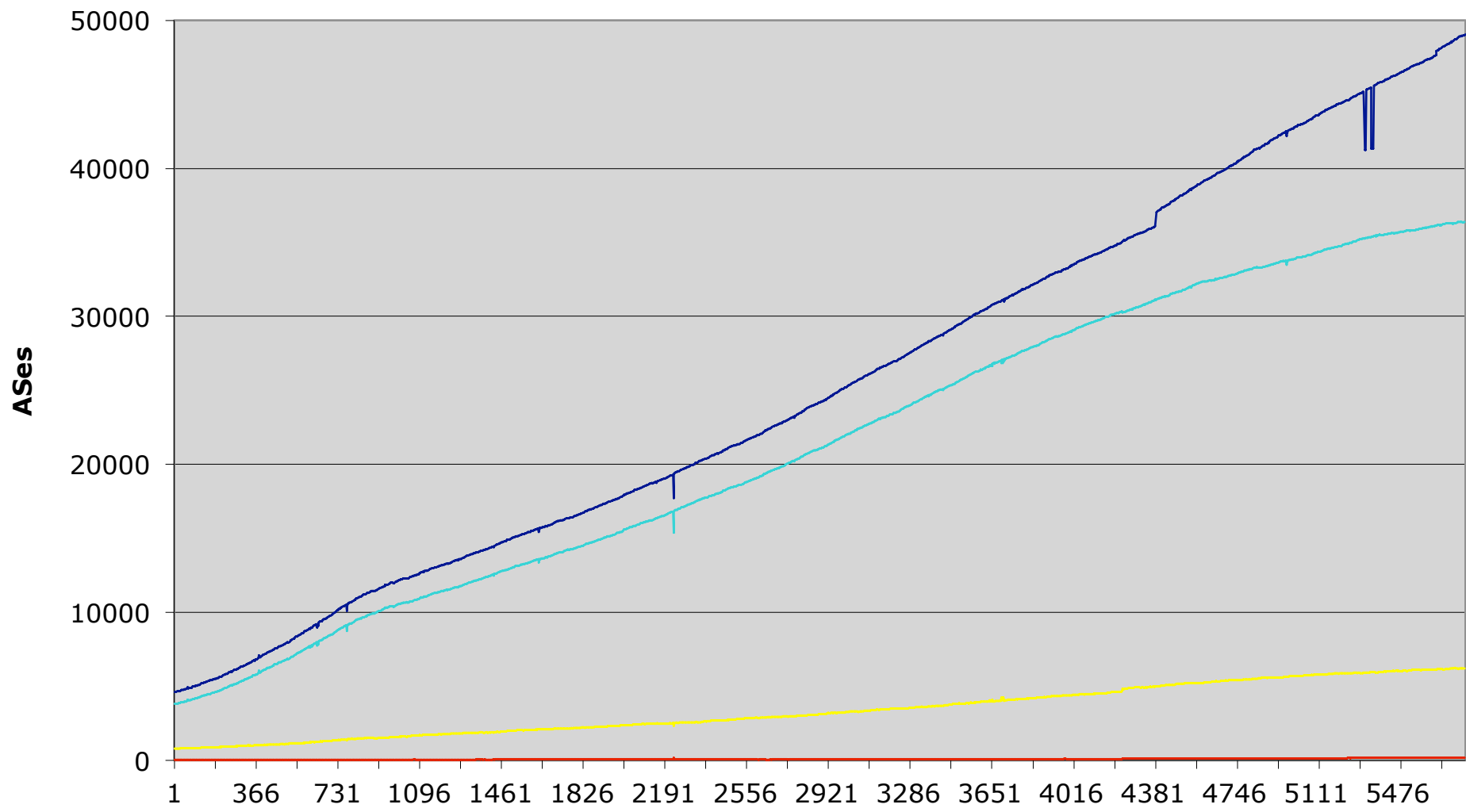


— /24s — Global BGP Table

# Address Space announced

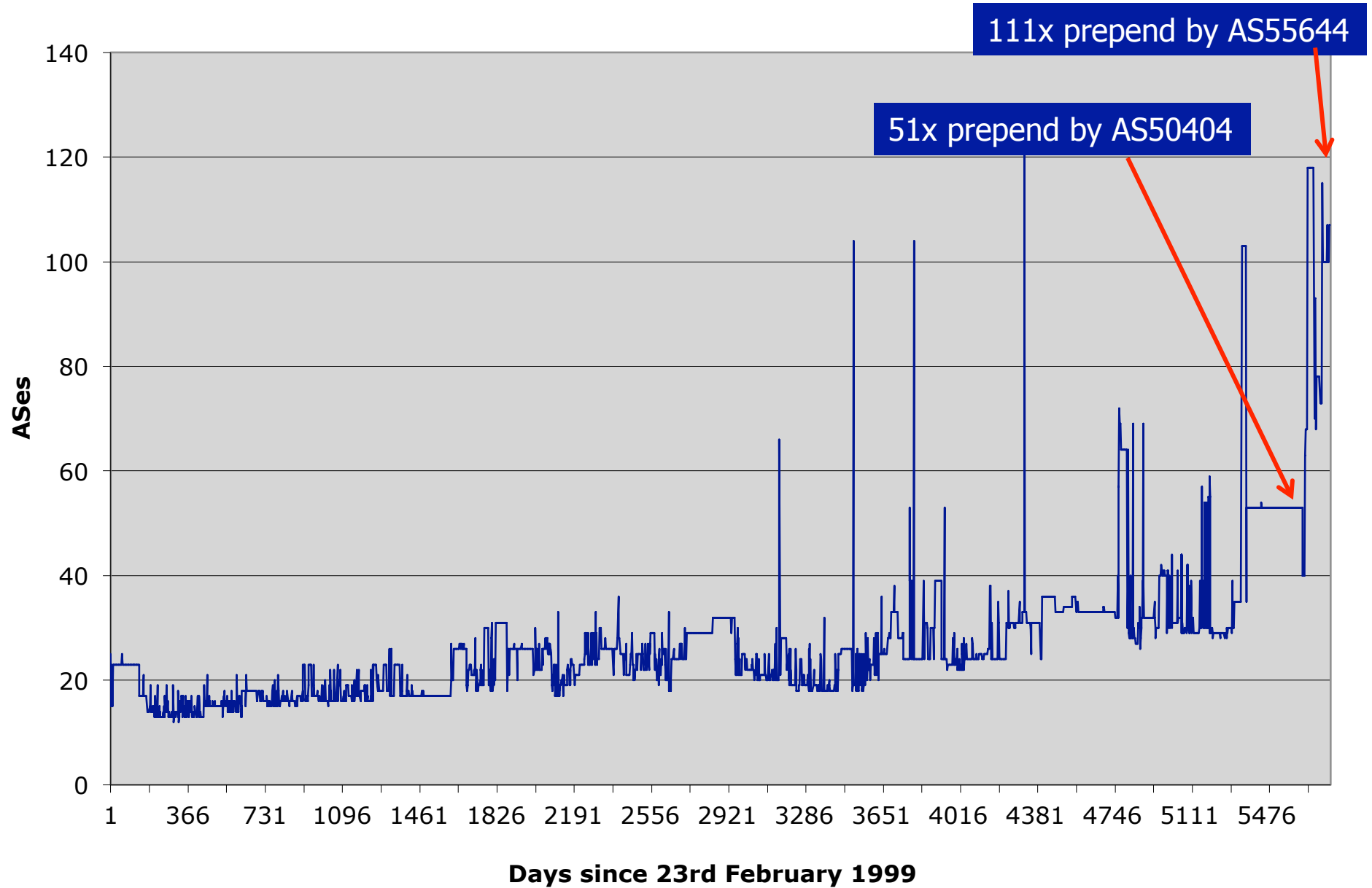


# AS Announcements



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

# Maximum AS Path Length





# Looking at Deaggregation

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- CIDR Report
  - [www.cidr-report.org](http://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

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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”



# January 2015

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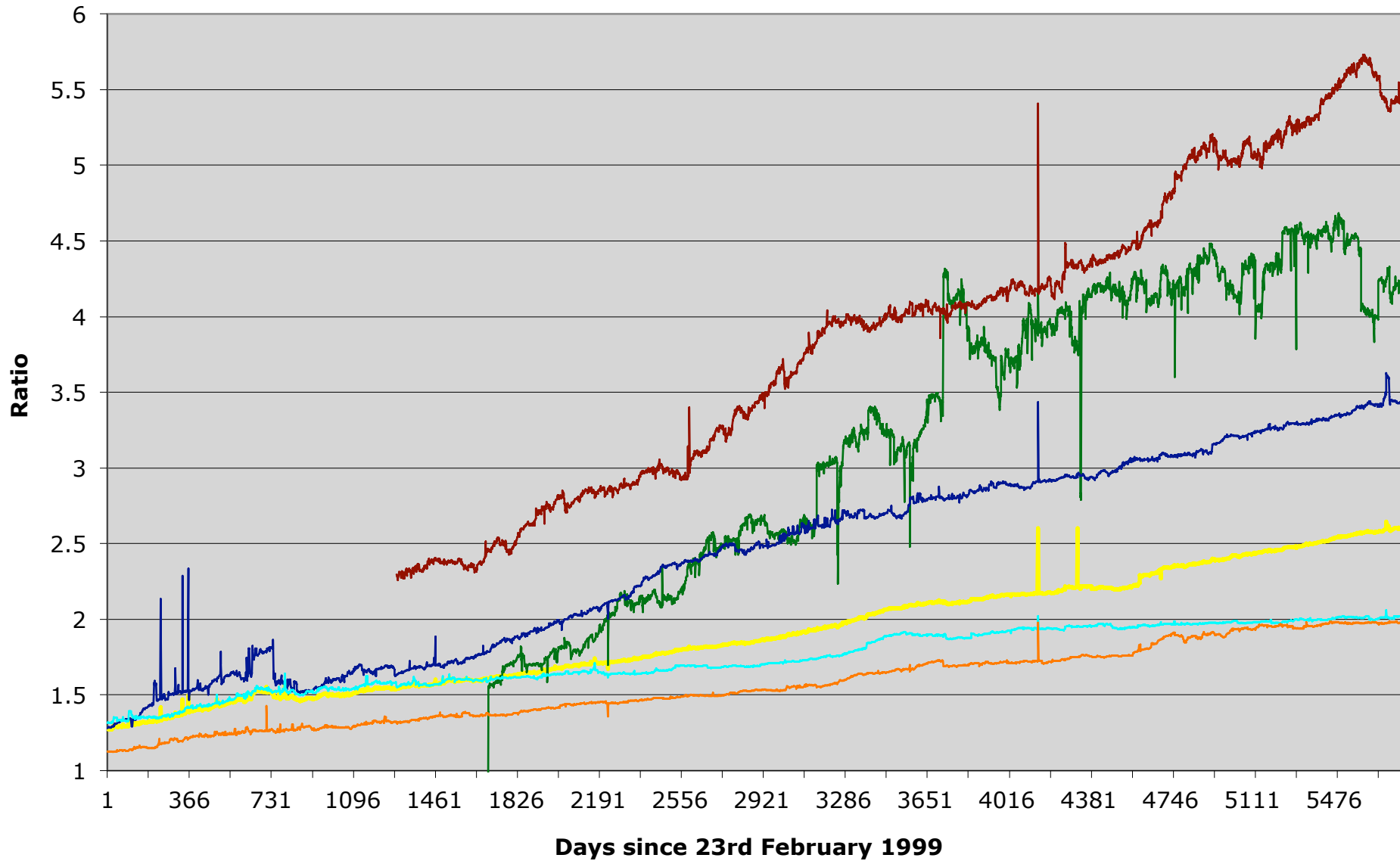
## Total Prefixes

- Global BGP Table
  - 526k prefixes
- Europe & Middle East
  - 126k prefixes
- North America
  - 175k prefixes
- Asia & Pacific
  - 130k prefixes
- Africa
  - 12k prefixes
- Latin America & Caribbean
  - 59k prefixes

## Deaggregation Factor

- Global Average
  - 2.60
- Europe & Middle East
  - 1.98
- North America
  - 2.02
- Asia & Pacific
  - 3.40
- Africa
  - 4.17
- Latin America & Caribbean
  - 5.41

## Deaggregation: RIR Regions vs Global



Global AfriNIC APNIC ARIN LACNIC RIPE

## Asia Pacific Aggregation Savings Summary

ASN	No of Nets	Savings	Description
17974	2827	2750	PT Telekomunikasi Indonesia
7545	2495	2367	TPG Telecom Limited
4766	2912	2002	Korea Telecom
4755	1933	1742	TATA Communications formerly
4538	1757	1686	China Education and Research
9829	1675	1647	National Internet Backbone
9808	1523	1504	Guangdong Mobile Communicatio
9498	1299	1202	BHARTI Airtel Ltd.
4788	1133	1076	TM Net, Internet Service Prov
38197	1161	1049	Sun Network (Hong Kong) Limit
4808	1459	1023	CNCGROUP IP network China169
24560	1198	1005	Bharti Airtel Ltd., Telemedia
7552	1010	998	Viettel Corporation
4780	1069	992	Digital United Inc.
17488	1121	859	Hathway IP Over Cable Interne
9583	1394	821	Sify Limited
18101	954	761	Reliance Communications Ltd.D
17908	837	752	Tata Communications
55430	748	726	Starhub Internet Pte Ltd
45528	782	707	Tikona Digital Networks Pvt L

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



# Importance of Aggregation

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- 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 11 January 2015 06:28 (UTC+1000)

## 50 Most active ASes for the past 7 days

RANK	ASN	UPDs	%	Prefixes	UPDs/Prefix	AS NAME
1	23752	322620	7.89%	140	2304.43	NPTELECOM-NP-AS Nepal Telecommunications Corporation, Internet Services,NP
2	9829	162058	3.96%	1676	96.69	BSNL-NIB National Internet Backbone,IN
3	22047	90699	2.22%	4293	21.13	VTR BANDA ANCHA S.A.,CL
4	53249	80223	1.96%	2	40111.50	LAWA-AS - Los Angeles World Airport,US
5	45899	71956	1.76%	810	88.83	VNPT-AS-VN VNPT Corp,VN
6	9198	54024	1.32%	862	62.67	KAZTELECOM-AS JSC Kazakhtelecom,KZ
7	38197	51252	1.25%	1161	44.14	SUNHK-DATA-AS-AP Sun Network (Hong Kong) Limited,HK
8	3	47270	1.16%	3	15756.67	MIT-GATEWAYS - Massachusetts Institute of Technology,US
9	17099	40038	0.98%	13	3079.85	CALLIS-COMMUNICATIONS-AS - Callis Communications,US
10	10620	36064	0.88%	3064	11.77	Telmex Colombia S.A.,CO
11	9583	35266	0.86%	1426	24.73	SIFY-AS-IN Sify Limited,IN
12	36925	32196	0.79%	79	407.54	ASMedi,MA
13	7552	29957	0.73%	1132	26.46	VIETEL-AS-AP Viettel Corporation,VN
14	28024	27915	0.68%	1526	18.29	Nuevatel PCS de Bolivia S.A.,BO
15	64512	25480	0.62%	17	1498.82	-Private Use AS-,ZZ
16	3816	25472	0.62%	922	27.63	COLOMBIA TELECOMUNICACIONES S.A. ESP,CO
17	60725	25426	0.62%	18	1412.56	O3B-AS O3b Limited,JE
18	12066	23482	0.57%	447	52.53	TRICOM,DO
19	31148	22883	0.56%	1045	21.90	FREENET-AS Freenet Ltd.,UA
20	48159	22847	0.56%	288	79.33	TIC-AS Telecommunication Infrastructure Company,IR
21	11054	22179	0.54%	36	616.08	LIVEPERSON - LivePerson, Inc.,US
22	23342	22157	0.54%	39	568.13	UNITEDLAYER - Unitedlayer, Inc.,US
23	9038	21664	0.53%	59	367.19	BAT-AS9038 Batelco Jordan,JO
24	28642	19643	0.48%	35	561.23	Contato Internet Ltda EPP,BR
25	25003	19625	0.48%	38	516.45	INTERNET_BINAT Internet Binat Ltd,IL

## 50 Most active Prefixes for the past 7 days

RANK	PREFIX	UPDs	%	Origin AS -- AS NAME
1	202.70.64.0/21	161787	3.73%	23752 -- NPTELECOM-NP-AS Nepal Telecommunications Corporation, Internet Services,NP
2	202.70.88.0/21	160309	3.69%	23752 -- NPTELECOM-NP-AS Nepal Telecommunications Corporation, Internet Services,NP
4	198.140.114.0/24	40131	0.92%	53249 -- LAWA-AS - Los Angeles World Airport,US
5	198.140.115.0/24	40092	0.92%	53249 -- LAWA-AS - Los Angeles World Airport,US
6	64.29.130.0/24	22154	0.51%	23342 -- UNITEDLAYER - Unitedlayer, Inc.,US
7	192.115.44.0/22	19417	0.45%	25003 -- INTERNET_BINAT Internet Binat Ltd,IL
8	185.26.155.0/24	13361	0.31%	60725 -- O3B-AS O3b Limited,JE
9	182.50.246.0/24	12169	0.28%	45786 -- HTSNET-AS-ID HTSNET - ISP,ID 65534 -- -Private Use AS-,ZZ
10	162.249.183.0/24	12054	0.28%	60725 -- O3B-AS O3b Limited,JE
11	192.58.232.0/24	10687	0.25%	6629 -- NOAA-AS - NOAA,US
12	42.83.48.0/20	9998	0.23%	18135 -- BTV BTV Cable television,JP
13	91.235.169.0/24	9835	0.23%	61039 -- ZMZ OAO ZMZ,RU
14	88.87.160.0/19	9545	0.22%	47680 -- NHCS EOBO Limited,IE
15	199.38.164.0/23	9007	0.21%	53563 -- XPLUSONE - X Plus One Solutions, Inc.,US
16	197.230.128.0/17	8314	0.19%	36925 -- ASMedi,MA 64512 -- -Private Use AS-,ZZ
17	41.214.192.0/18	8296	0.19%	36925 -- ASMedi,MA 64512 -- -Private Use AS-,ZZ
18	197.253.128.0/17	8236	0.19%	36925 -- ASMedi,MA 64512 -- -Private Use AS-,ZZ
19	105.188.0.0/14	7880	0.18%	36925 -- ASMedi,MA 64512 -- -Private Use AS-,ZZ
20	197.153.0.0/16	7872	0.18%	36925 -- ASMedi,MA 64512 -- -Private Use AS-,ZZ
21	41.92.0.0/17	7855	0.18%	36925 -- ASMedi,MA 64512 -- -Private Use AS-,ZZ
22	41.214.160.0/19	7823	0.18%	36925 -- ASMedi,MA 64512 -- -Private Use AS-,ZZ
23	192.136.55.0/24	6545	0.15%	25543 -- FasoNet-AS,BF
24	206.152.15.0/24	5892	0.14%	54465 -- QPM-AS-1 - QuickPlay Media Inc.,US
25	109.160.4.0/22	5084	0.12%	62174 -- INTERPAN-AS INTERPAN LTD.,BG



# Observations

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- 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



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Questions?