

# Internet IPv4 Routing Table Analysis Update



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SANOG 27

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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 24 January 2016

BGP routing table entries examined:	579418
Prefixes after maximum aggregation (per Origin AS):	214050
Deaggregation factor:	2.71
Unique aggregates announced (without unneeded subnets):	282412
Total ASes present in the Internet Routing Table:	52565
Prefixes per ASN:	11.02
Origin-only ASes present in the Internet Routing Table:	36595
Origin ASes announcing only one prefix:	15825
Transit ASes present in the Internet Routing Table:	6412
Transit-only ASes present in the Internet Routing Table:	170
Average AS path length visible in the Internet Routing Table:	4.4
Max AS path length visible:	37
Max AS path prepend of ASN ( 40285)	34
Prefixes from unregistered ASNs in the Routing Table:	995
Unregistered ASNs in the Routing Table:	361
Number of 32-bit ASNs allocated by the RIRs:	12464
Number of 32-bit ASNs visible in the Routing Table:	9558
Prefixes from 32-bit ASNs in the Routing Table:	36678
Number of bogon 32-bit ASNs visible in the Routing Table:	16
Special use prefixes present in the Routing Table:	0
Prefixes being announced from unallocated address space:	407
Number of addresses announced to Internet:	2802377156
Equivalent to 167 /8s, 8 /16s and 225 /24s	
Percentage of available address space announced:	75.7
Percentage of allocated address space announced:	75.7
Percentage of available address space allocated:	100.0
Percentage of address space in use by end-sites:	98.0
Total number of prefixes smaller than registry allocations:	190301

## APNIC Region

Prefixes being announced by APNIC Region ASes:	147807
Total APNIC prefixes after maximum aggregation:	40760
APNIC Deaggregation factor:	3.63
Prefixes being announced from the APNIC address blocks:	156777
Unique aggregates announced from the APNIC address blocks:	63473
APNIC Region origin ASes present in the Internet Routing Table:	5124
APNIC Prefixes per ASN:	30.60
APNIC Region origin ASes announcing only one prefix:	1179
APNIC Region transit ASes present in the Internet Routing Table:	906
Average APNIC Region AS path length visible:	4.5
Max APNIC Region AS path length visible:	35
Number of APNIC region 32-bit ASNs visible in the Routing Table:	1820
Number of APNIC addresses announced to Internet:	751778692
Equivalent to 44 /8s, 207 /16s and 59 /24s	
Percentage of available APNIC address space announced:	87.9

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
4538	5599	4192	76	China Education and Research
10620	3415	541	143	Telmex Colombia S.A.
22773	3296	2949	147	Cox Communications Inc.
7545	3138	348	162	TPG Telecom Limited
4766	3115	11143	1094	Korea Telecom
17974	2854	914	96	PT Telekomunikasi Indonesia
3356	2601	10692	531	Level 3 Communications, Inc.
39891	2515	135	9	SaudiNet, Saudi Telecom Compa
6389	2475	3687	42	BellSouth.net Inc.
20940	2342	924	1670	Akamai International B.V.
9829	2322	1435	385	National Internet Backbone
18566	2209	394	277	MegaPath Corporation
8151	2177	3387	521	Uninet S.A. de C.V.
4755	2079	432	234	TATA Communications formerly
34984	1939	322	414	TELLCOM ILETISIM HIZMETLERI A
20115	1907	1908	410	Charter Communications
9808	1763	8717	29	Guangdong Mobile Communicatio
6983	1696	849	238	EarthLink, Inc.
30036	1672	332	348	Mediacom Communications Corp
4808	1620	2280	509	CNCGROUP IP network China169

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	/11:101	/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				

January 2016 ↑

January 2015 ↓

## Number of prefixes announced by prefix length

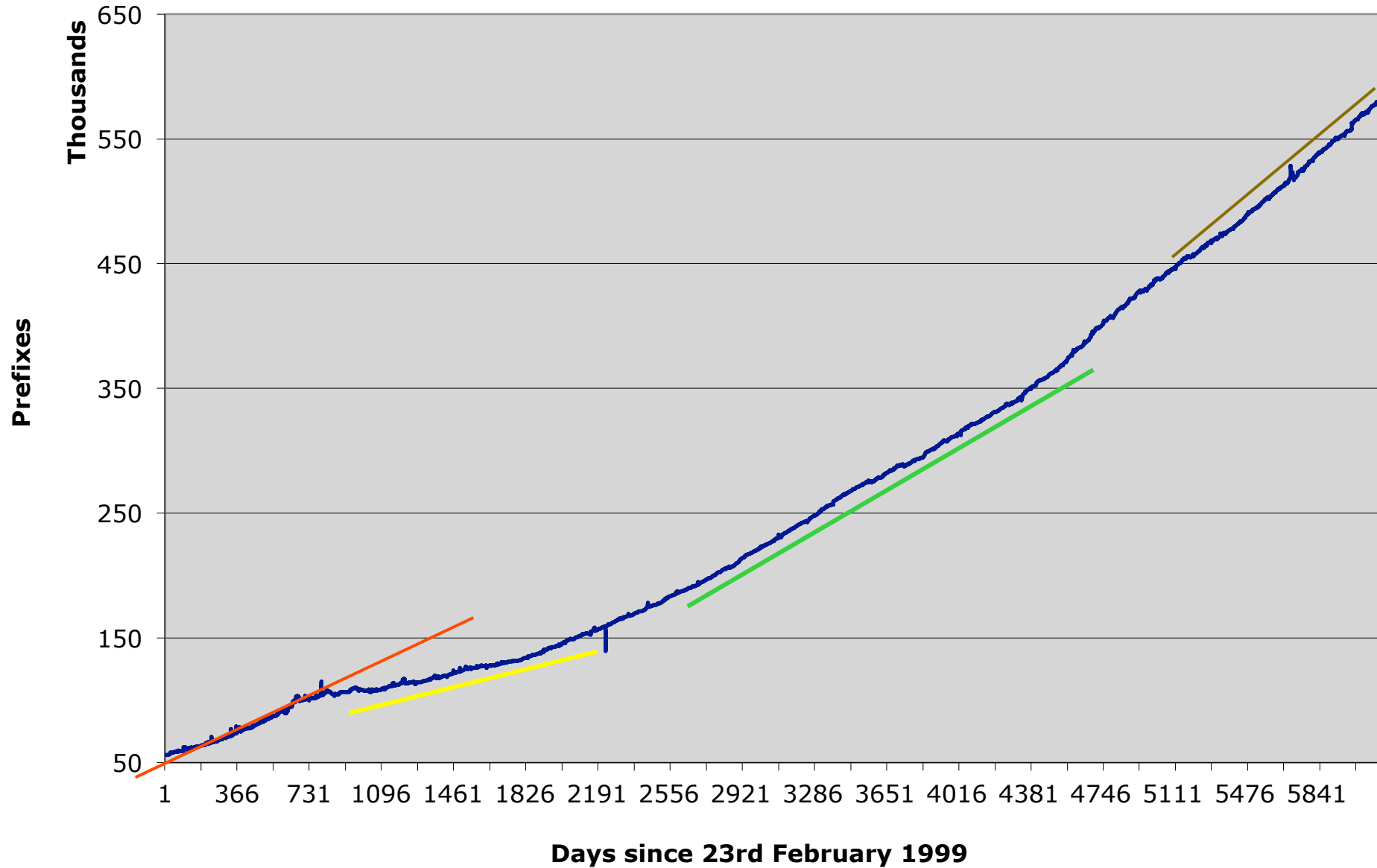
/1:0	/2:0	/3:0	/4:0	/5:0	/6:0
/7:0	/8:16	/9:12	/10:31	/11:92	/12:265
/13:502	/14:998	/15:1724	/16:13049	/17:7194	/18:12031
/19:24907	/20:35645	/21:38191	/22:56730	/23:49309	/24:282556
/25:1146	/26:1083	/27:679	/28:17	/29:14	/30:10
/31:0	/32:9				

## Prefixes Smaller than Registry Allocations

ASN	No of nets	Total ann.	Description
22773	2478	3296	Cox Communications Inc.
39891	2472	2515	SaudiNet, Saudi Telecom Compa
18566	2111	2209	MegaPath Corporation
6389	1542	2475	BellSouth.net Inc.
30036	1489	1672	Mediacom Communications Corp
6983	1342	1696	EarthLink, Inc.
10620	1295	3415	Telmex Colombia S.A.
34984	1228	1939	TELLCOM ILETISIM HIZMETLERI A
11492	1156	1248	CABLE ONE, INC.
31148	960	1043	Freenet Ltd.
22561	915	1178	CenturyTel Internet Holdings,
13188	892	1077	TOV "Bank-Inform"
11830	882	1434	Instituto Costarricense de El
8452	863	1297	TE-AS
13977	805	838	FAIRPOINT COMMUNICATIONS, INC
6503	772	1399	Axtel, S.A.B. de C.V.
27738	762	784	Ecuadortelecom S.A.
4766	723	3115	Korea Telecom
8551	723	1225	Bezeq International-Ltd
3356	715	2601	Level 3 Communications, Inc.

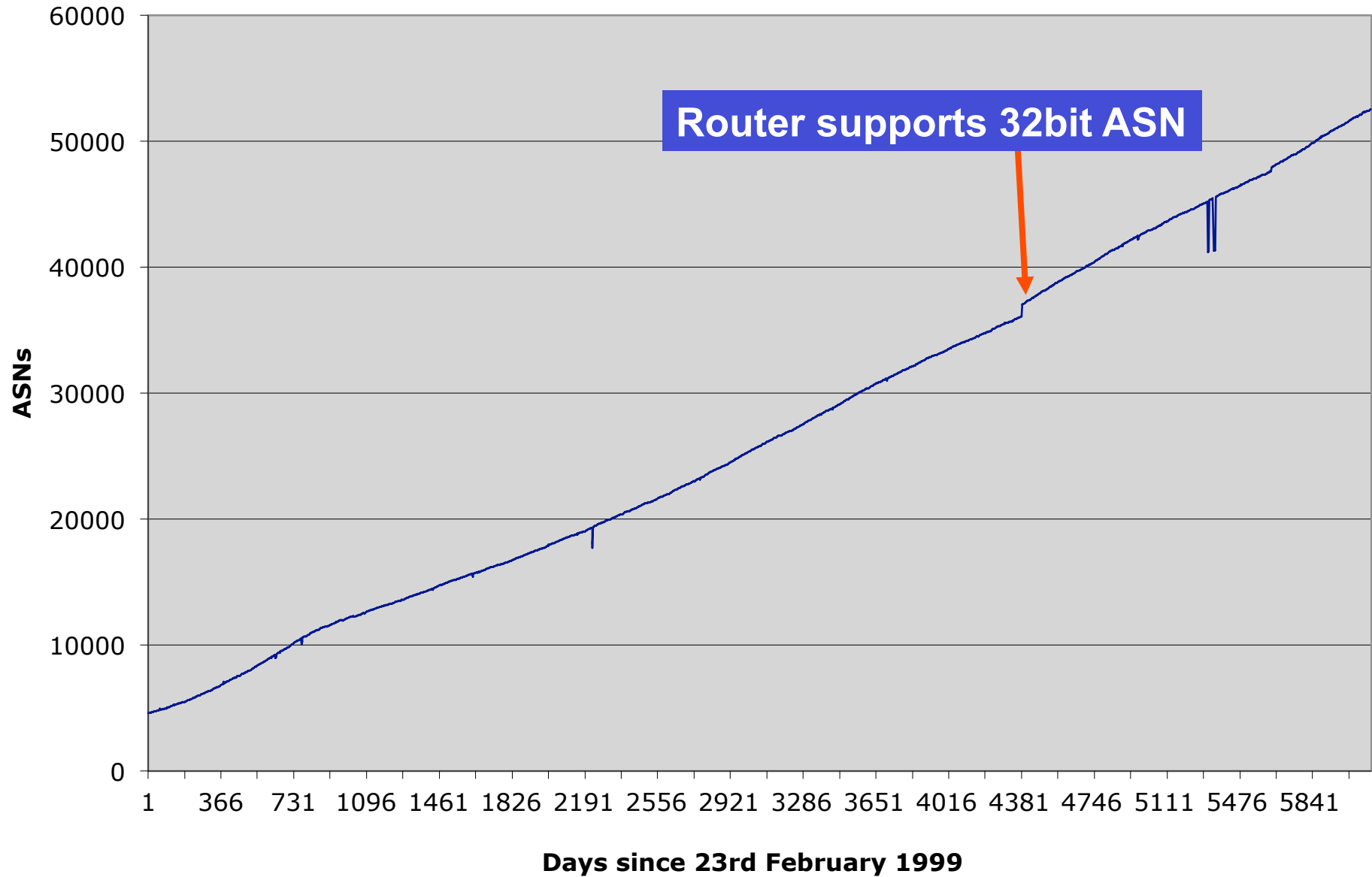
AfriNIC APNIC ARIN LACNIC RIPE NCC

# BGP Routing Table

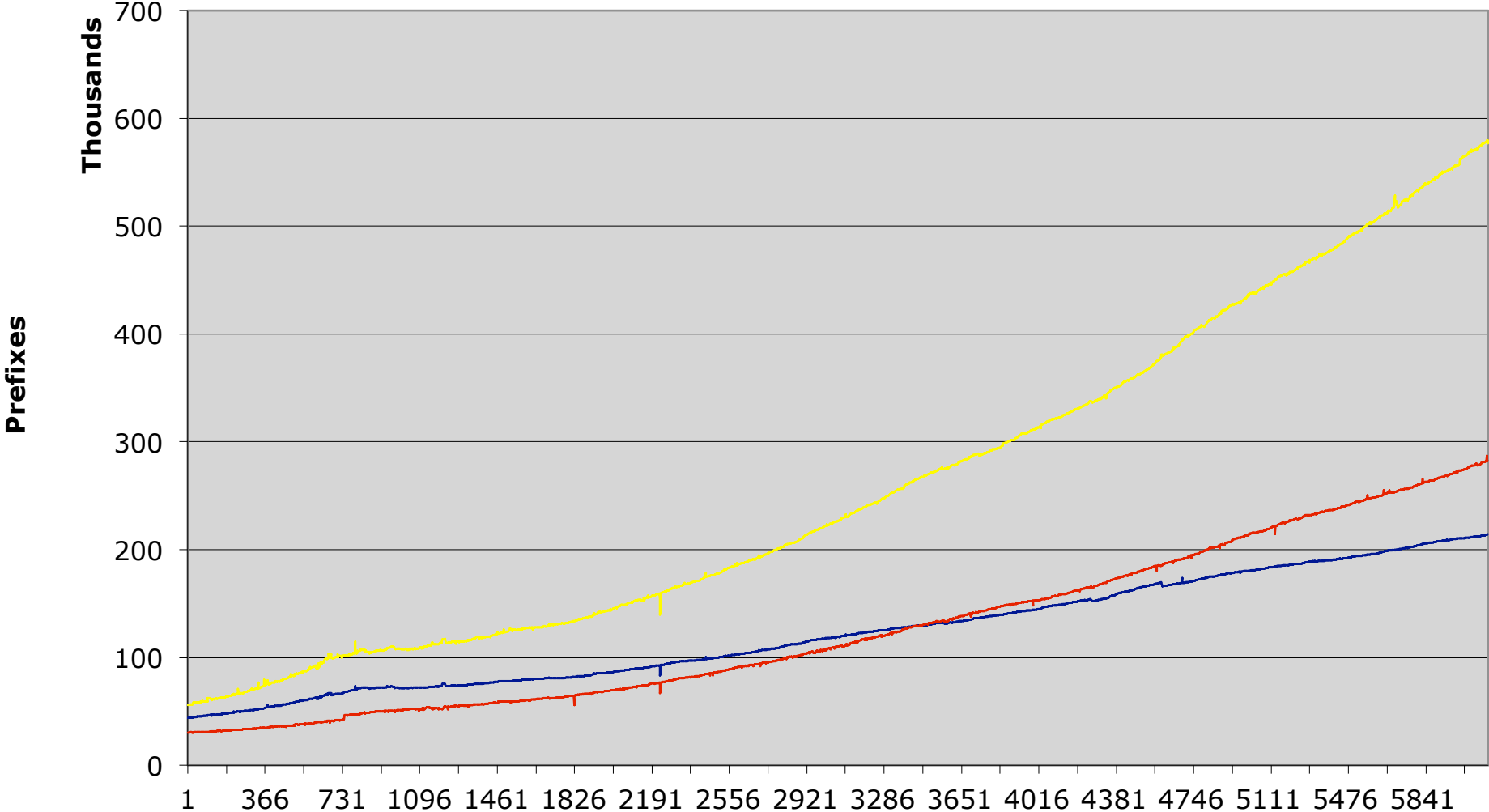




# AS Growth

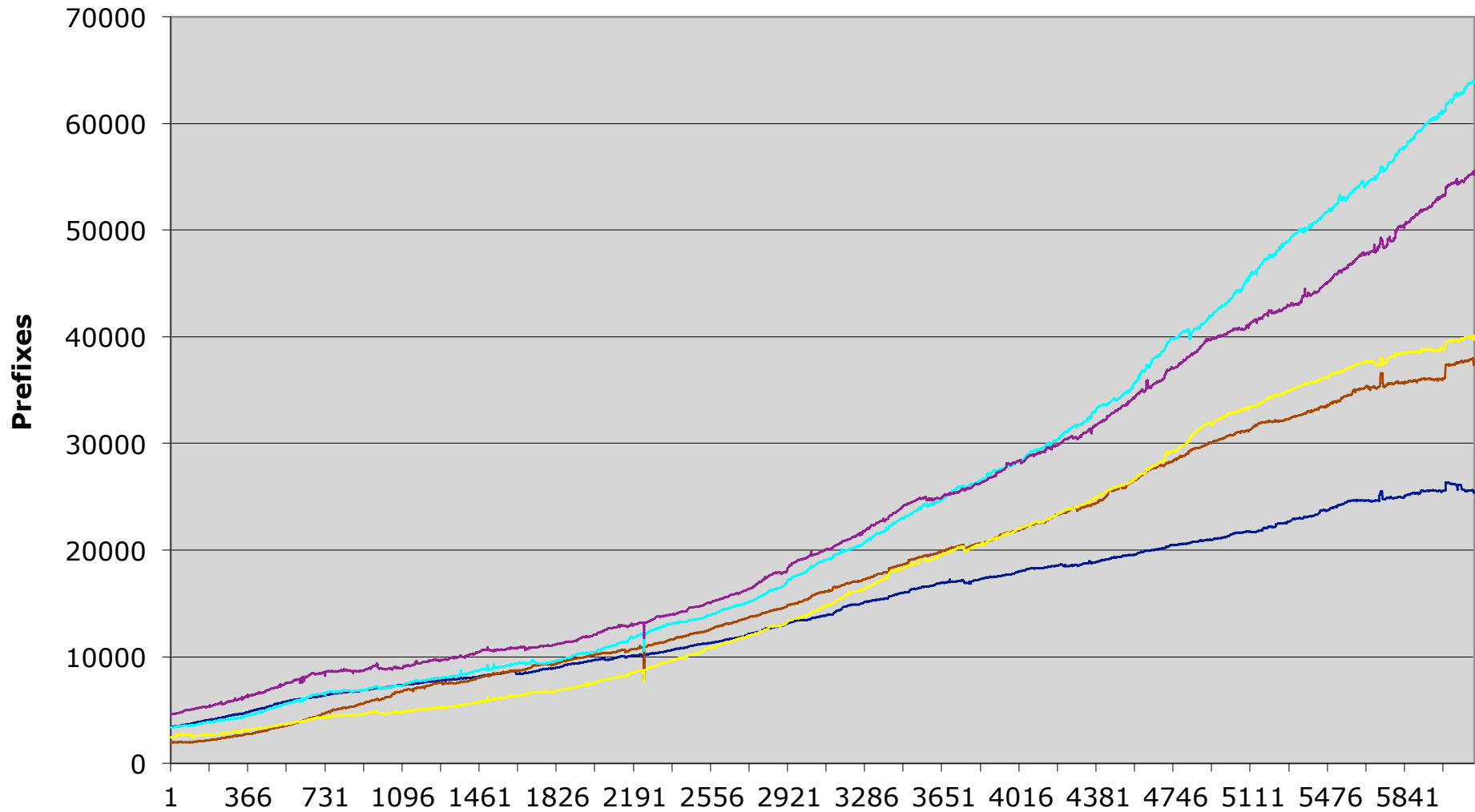


# Max Aggregation vs Unique Prefixes



— Max Aggregation    — Unique Prefixes    — Global BGP Table

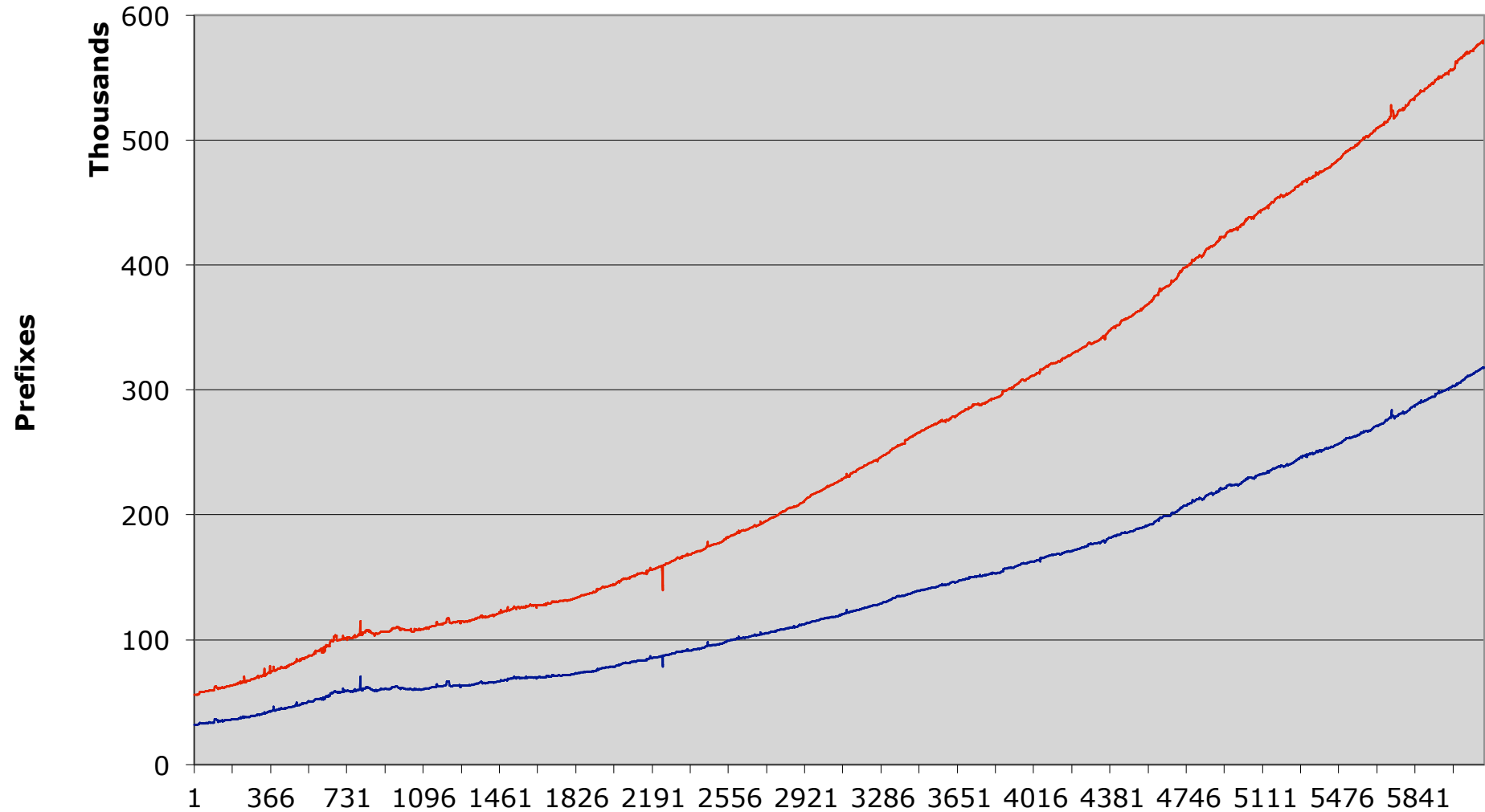
# Prefix sizes announced



Days since 23rd February 1999

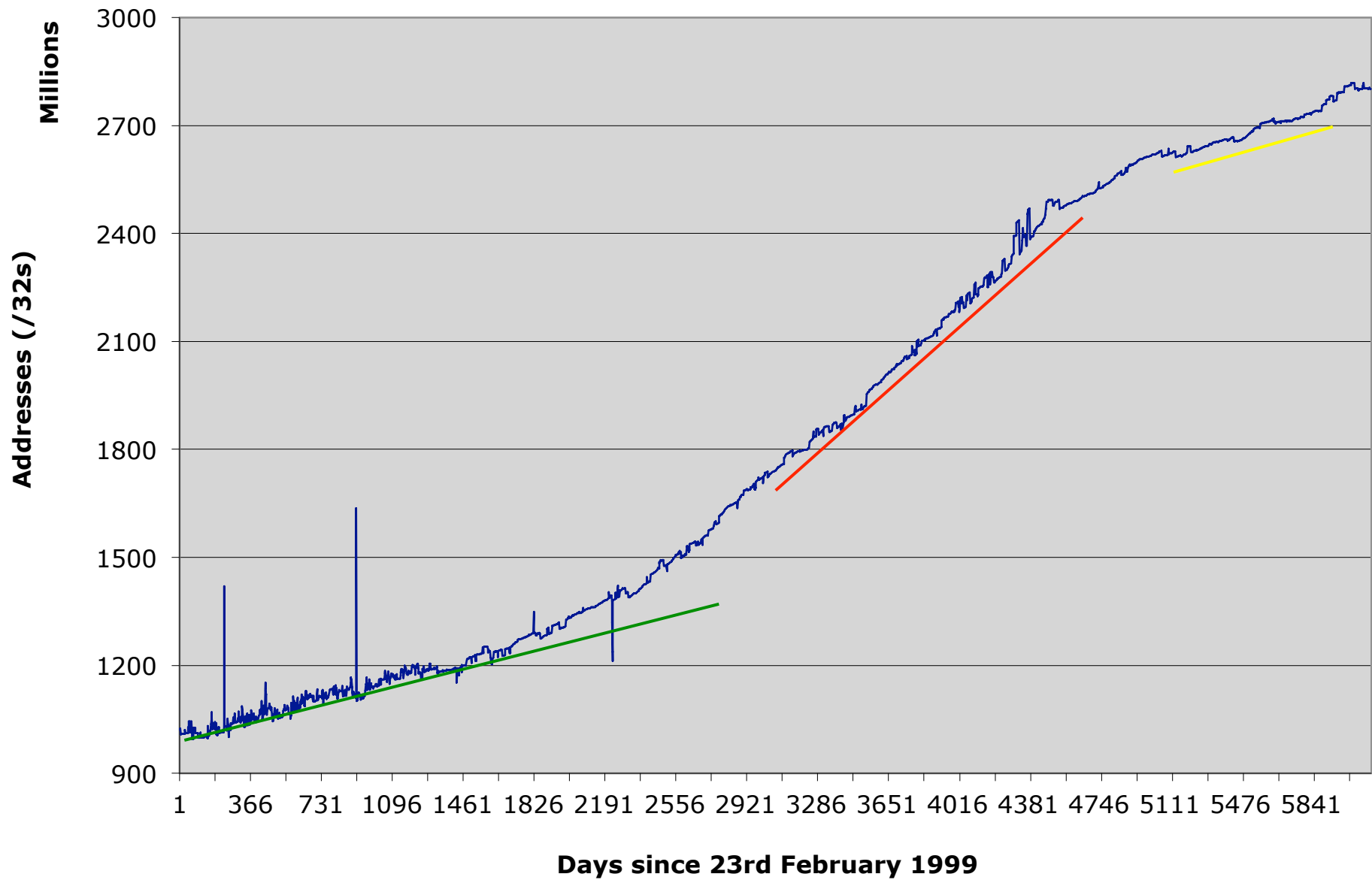
— /19 — /20 — /21 — /22 — /23

# /24s announced

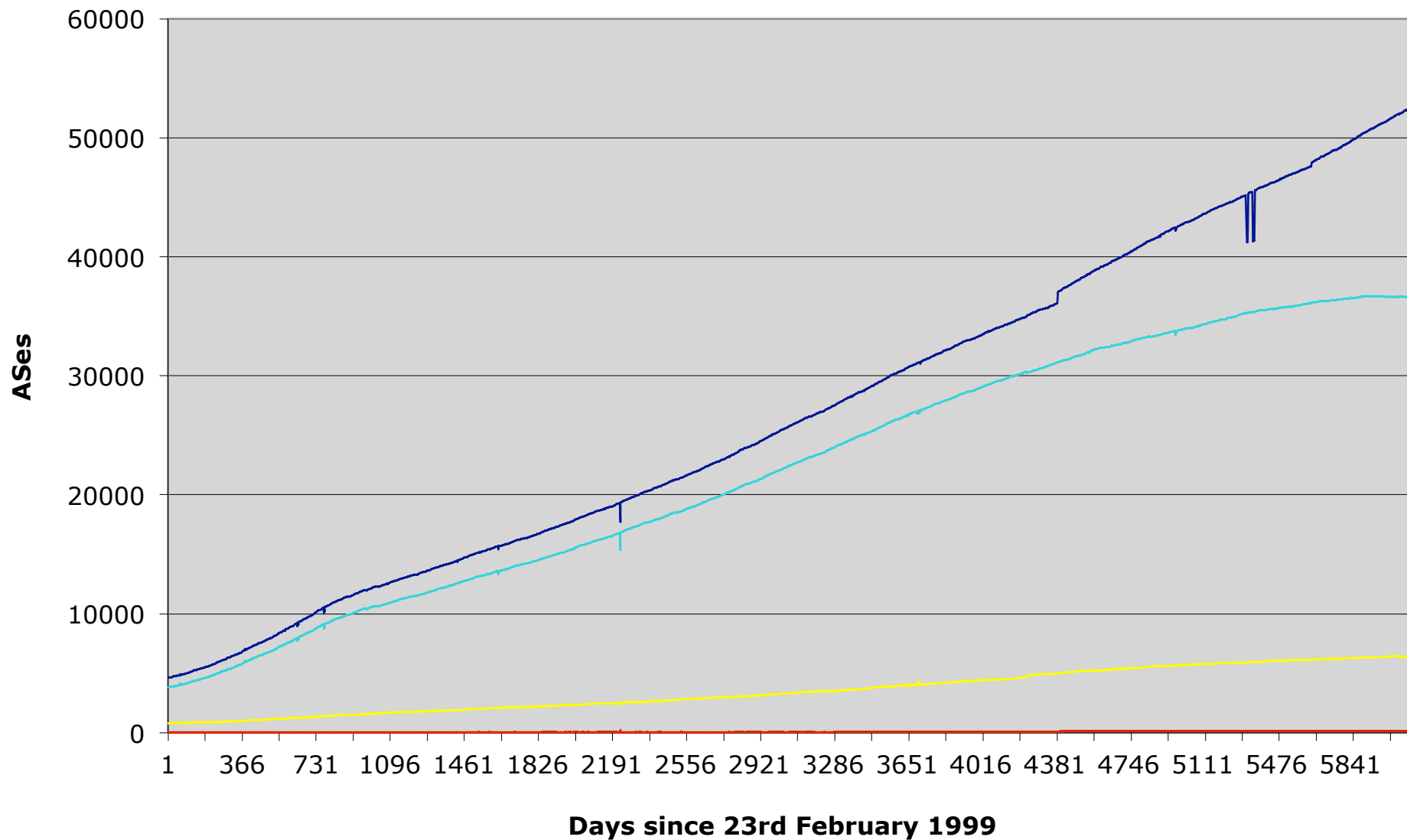


— /24s    — Global BGP Table

# Address Space announced

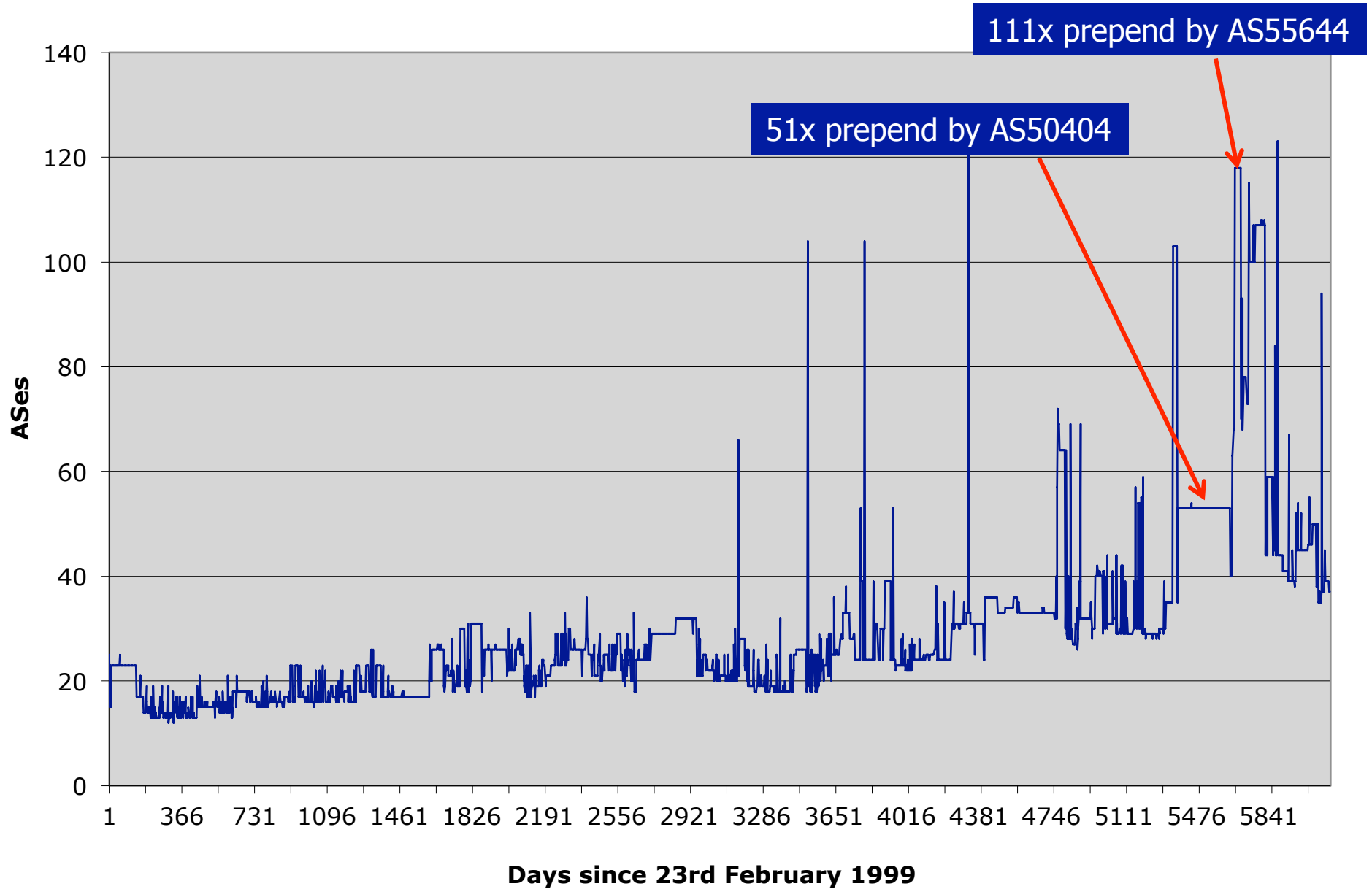


# AS Announcements



— 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 2016

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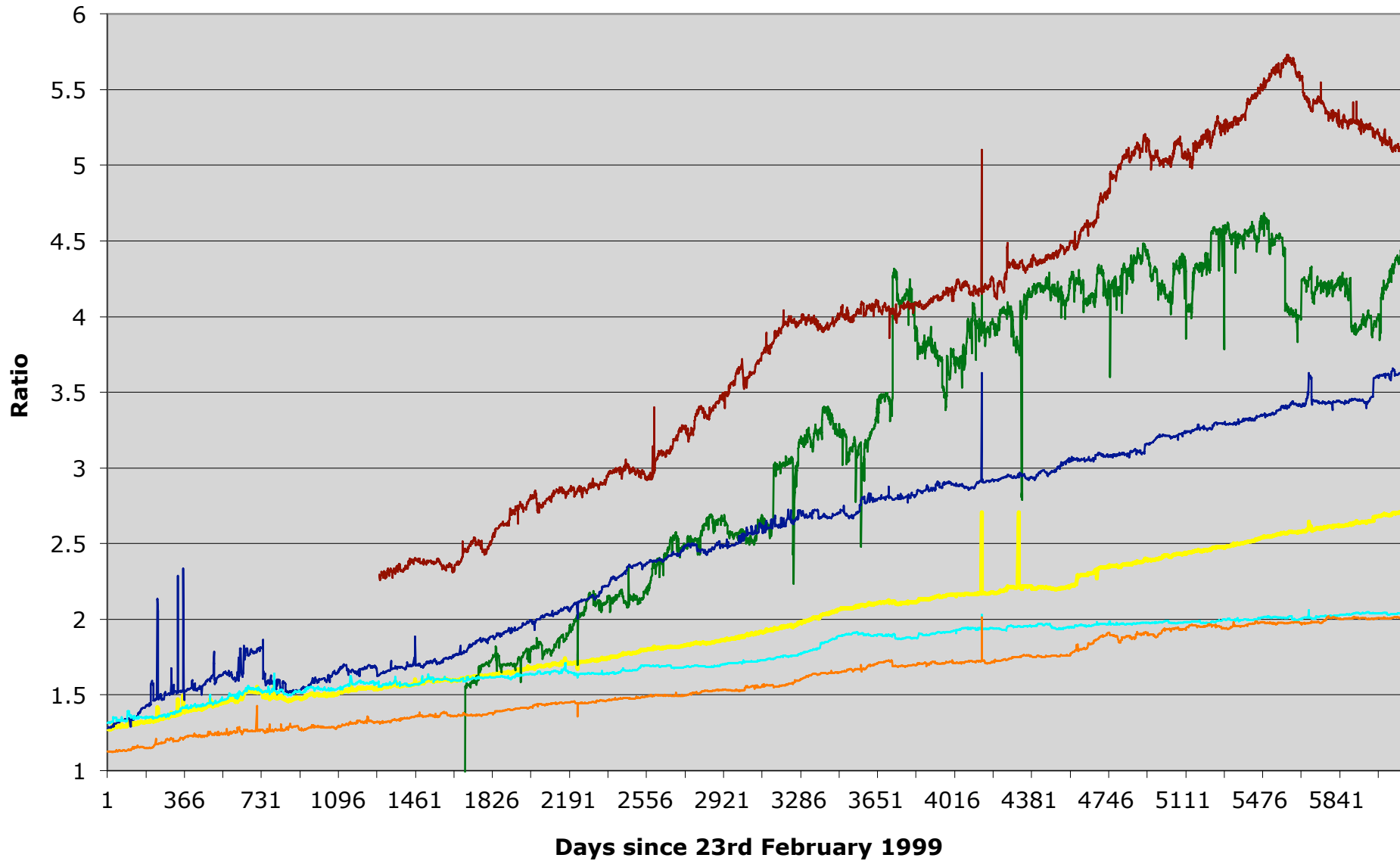
## Total Prefixes

- Global BGP Table
  - 579k prefixes
- Europe & Middle East
  - 139k prefixes
- North America
  - 180k prefixes
- Asia & Pacific
  - 148k prefixes
- Africa
  - 14k prefixes
- Latin America & Caribbean
  - 61k prefixes

## Deaggregation Factor

- Global Average
  - 2.71
- Europe & Middle East
  - 2.01
- North America
  - 2.03
- Asia & Pacific
  - 3.63
- Africa
  - 4.45
- Latin America & Caribbean
  - 5.10

## Deaggregation: RIR Regions vs Global



Global AfriNIC APNIC ARIN LACNIC RIPE

## Asia Pacific Aggregation Savings Summary

ASN	No of Nets	Savings	Description
7545	3138	2976	TPG Telecom Limited
17974	2854	2758	PT Telekomunikasi Indonesia
4766	3115	2021	Korea Telecom
9829	2322	1937	National Internet Backbone
4755	2079	1845	TATA Communications formerly
9808	1763	1734	Guangdong Mobile Communicatio
7552	1380	1360	Viettel Corporation
9498	1406	1294	BHARTI Airtel Ltd.
4788	1316	1256	TM Net, Internet Service Prov
38197	1424	1221	Sun Network (Hong Kong) Limit
17488	1424	1197	Hathway IP Over Cable Interne
24560	1372	1172	Bharti Airtel Ltd., Telemedia
45899	1297	1137	VNNIC
4808	1620	1111	CNCGROUP IP network China169
4780	1038	960	Digital United Inc.
9583	1515	955	Sify Limited
55430	976	950	Starhub Internet Pte Ltd
18403	961	950	The Corporation for Financing
45528	940	826	Tikona Digital Networks Pvt L
9394	809	787	China TieTong Telecommunicati

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

## Nepal Aggregation Savings Summary

ASN	No of Nets	Savings	Description
23752	164	158	Nepal Telecommunications Corp
4613	34	31	Mercantile Office Systems
24550	35	27	Websurfer Nepal Internet Serv
4007	36	20	Subisu Cablenet (Pvt) Ltd, Ba
45650	16	12	Vianet Communications Pvt. Lt
58504	10	8	TECHMINDS NETWORKS PVT. LTD.
55915	16	8	Classic Tech Pvt. Ltd.
18395	10	8	Infocom Pvt. Ltd
17501	13	8	WorldLink Communications Pvt
55427	8	6	Broadlink Nepal
59343	9	5	Otel Communication Pvt. Ltd
55763	4	3	H.B. COMPLEX JAWALAKHEL LALIT
45353	4	3	NITC: IT Agency of Government
63991	4	2	Arrownet Pvt.Ltd
59370	3	2	Access World Tech Pvt. Ltd.
58433	3	2	Himalayan Bank Ltd.
56204	3	2	Net Max Technologies Pvt. Ltd
45274	4	2	Worldlink International Trans
38217	4	2	Dataspace Pvt. Ltd.
23866	3	2	Square Net,

<http://thyme.apnic.net/current/data-NP.CIDR>



# 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 18 January 2016 06:23 (UTC+1000)

## 50 Most active ASes for the past 7 days

RANK	ASN	UPDs	%	Prefixes	UPDs/Prefix	AS NAME
1	9829	127252	5.82%	2319	54.87	BSNL-NIB National Internet Backbone,IN
2	132084	98695	4.52%	28	3524.82	OPSOURCE-AP 5201 Great America Pkwy # 120,AU
3	6849	66674	3.05%	657	101.48	UKRTELNET JSC UKRTELECOM,UA
4	28469	28673	1.31%	124	231.23	NII DIGITAL S DE RL DE CV,MX
5	13118	27803	1.27%	96	289.61	ASN-YARTELECOM PJSC Rostelecom,RU
6	45899	20318	0.93%	1276	15.92	VNPT-AS-VN VNPT Corp,VN
7	2697	19569	0.90%	182	107.52	ERX-ERNET-AS Education and Research Network,IN
8	8452	16127	0.74%	2710	5.95	TE-AS TE-AS,EG
9	9583	15944	0.73%	1519	10.50	SIFY-AS-IN Sify Limited,IN
10	8151	15592	0.71%	2180	7.15	Uninet S.A. de C.V.,MX
11	17908	15525	0.71%	805	19.29	TCISL Tata Communications,IN
12	246	14530	0.67%	276	52.64	ASIFICS-GW-AS - 754th Electronic Systems Group,US
13	38285	14016	0.64%	1172	11.96	M2TELECOMMUNICATIONS-AU M2 Telecommunications Group Ltd,AU
14	30036	13169	0.60%	1683	7.82	MEDIACOM-ENTERPRISE-BUSINESS - Mediacom Communications Corp,US
15	8402	12690	0.58%	1132	11.21	CORBINA-AS OJSC "Vimpelcom",RU
16	27947	12381	0.57%	378	32.75	Telconet S.A,EC
17	197068	12343	0.56%	16	771.44	QRATOR HLL LLC,RU
18	440	12199	0.56%	206	59.22	AFCONC-BLOCK1-AS - 754th Electronic Systems Group,US
19	11492	11738	0.54%	1246	9.42	CABLEONE - CABLE ONE, INC.,US
20	52690	11233	0.51%	17	660.76	VIA PERSONAL TECNOLOGIA, INFORMAÇÃO E COMUNICAÇÃO,BR
21	45271	11051	0.51%	537	20.58	ICLNET-AS-AP Idea Cellular Limited,IN
22	45194	11048	0.51%	345	32.02	SIPL-AS Syscon Infoway Pvt. Ltd.,IN
23	28548	10098	0.46%	52	194.19	Cablevisión, S.A. de C.V.,MX
24	37148	9851	0.45%	41	240.27	globacom-as,NG
25	28509	9714	0.44%	622	15.62	Cablemas Telecomunicaciones SA de CV,MX

## 50 Most active Prefixes for the past 7 days

RANK	PREFIX	UPDs	%	Origin AS -- AS NAME
1	93.181.192.0/19	24884	1.07%	13118 -- ASN-YARTELECOM PJSC Rostelecom,RU
2	168.128.113.0/24	19342	0.83%	132084 -- OPSOURCE-AP 5201 Great America Pkwy # 120,AU
3	168.128.73.0/24	18677	0.80%	132084 -- OPSOURCE-AP 5201 Great America Pkwy # 120,AU
4	185.65.148.0/24	12333	0.53%	197068 -- QRATOR HLL LLC,RU
5	168.128.119.0/24	10118	0.44%	132084 -- OPSOURCE-AP 5201 Great America Pkwy # 120,AU
6	168.128.117.0/24	10112	0.44%	132084 -- OPSOURCE-AP 5201 Great America Pkwy # 120,AU
7	168.128.118.0/24	10112	0.44%	132084 -- OPSOURCE-AP 5201 Great America Pkwy # 120,AU
8	168.128.116.0/24	10112	0.44%	132084 -- OPSOURCE-AP 5201 Great America Pkwy # 120,AU
9	168.128.115.0/24	10111	0.44%	132084 -- OPSOURCE-AP 5201 Great America Pkwy # 120,AU
10	168.128.114.0/24	10111	0.44%	132084 -- OPSOURCE-AP 5201 Great America Pkwy # 120,AU
11	195.128.159.0/24	9673	0.42%	56636 -- ASVEDARU VEDA Ltd.,RU
12	202.41.70.0/24	8745	0.38%	2697 -- ERX-ERNET-AS Education and Research Network,IN
13	202.41.83.0/24	8452	0.36%	2697 -- ERX-ERNET-AS Education and Research Network,IN
14	66.19.194.0/24	6543	0.28%	6316 -- AS-PAETEC-NET - PaeTec Communications, Inc.,US
15	197.112.0.0/13	6123	0.26%	36947 -- ALGTEL-AS,DZ
16	184.82.0.0/20	5658	0.24%	133481 -- SBN-FBB-AS-AP Fixed Broadband Network,TH
17	173.17.37.0/24	5314	0.23%	30036 -- MEDIACOM-ENTERPRISE-BUSINESS - Mediacom Communications Corp,US
18	67.61.206.0/24	5226	0.22%	11492 -- CABLEONE - CABLE ONE, INC.,US
19	67.61.207.0/24	5224	0.22%	11492 -- CABLEONE - CABLE ONE, INC.,US
20	185.78.104.0/24	4773	0.21%	34341 -- NCEM Namvaran Consulting Engineers and Managers,IR
21	203.55.16.0/24	4442	0.19%	10113 -- EFTEL-AS-AP Eftel Limited.,AU
22	110.170.17.0/24	3690	0.16%	134438 -- AIRAAIFUL-AS-AP Aira & Aiful Public Company Limited,TH
23	94.73.56.0/21	3615	0.16%	42081 -- SPEEDY-NET-AS Speedy net AD,BG
24	148.208.214.0/24	3344	0.14%	8151 -- Uninet S.A. de C.V.,MX
25	211.29.16.0/21	3166	0.14%	4804 -- MPX-AS Microplex PTY LTD,AU
26	205.162.134.0/24	2978	0.13%	23541 -- Scarlet B.V.,CW
27	144.36.107.0/24	2910	0.13%	3573 -- ACCENTURE - Accenture LLP,US
28	2.93.235.0/24	2832	0.12%	8402 -- CORBINA-AS OJSC "Vimpelcom",RU
29	84.205.66.0/24	2694	0.12%	12654 -- RIPE-NCC-RIS-AS Reseaux IP Europeens Network Coordination Centre (RIPE NCC),EU





# 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?