

# Internet IPv4 Routing Table Analysis Update



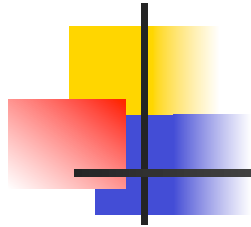
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BTNOG 1

16<sup>th</sup> November 2014

Phuentsholing



# 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 23rd February 1999:
  - Routing table size
  - CIDR-Report style reporting on a per-RIR basis
  - ...and many other interesting features

# Routing Report      16 November 2014

BGP routing table entries examined:	523098
Prefixes after maximum aggregation:	199961
Deaggregation factor:	2.62
Unique aggregates announced to Internet:	254130
Total ASes present in the Internet Routing Table:	48557
Prefixes per ASN:	10.77
Origin-only ASes present in the Internet Routing Table:	36268
Origin ASes announcing only one prefix:	16318
Transit ASes present in the Internet Routing Table:	6205
Transit-only ASes present in the Internet Routing Table:	174
Average AS path length visible in the Internet Routing Table:	4.5
Max AS path length visible:	78
Max AS path prepend of ASN ( 55644)	71
Prefixes from unregistered ASNs in the Routing Table:	1592
Unregistered ASNs in the Routing Table:	426
Number of 32-bit ASNs allocated by the RIRs:	7922
Number of 32-bit ASNs visible in the Routing Table:	6084
Prefixes from 32-bit ASNs in the Routing Table:	21788
Number of bogon 32-bit ASNs visible in the Routing Table:	2
Special use prefixes present in the Routing Table:	0
Prefixes being announced from unallocated address space:	387
Number of addresses announced to Internet:	2713783940
Equivalent to 161 /8s, 193 /16s and 14 /24s	
Percentage of available address space announced:	73.3
Percentage of allocated address space announced:	73.3
Percentage of available address space allocated:	100.0
Percentage of address space in use by end-sites:	96.9
Total number of prefixes smaller than registry allocations:	176990

## APNIC Region

Prefixes being announced by APNIC Region ASes:	132708
Total APNIC prefixes after maximum aggregation:	36979
APNIC Deaggregation factor:	3.59
Prefixes being announced from the APNIC address blocks:	137086
Unique aggregates announced from the APNIC address blocks:	53713
APNIC Region origin ASes present in the Internet Routing Table:	4988
APNIC Prefixes per ASN:	27.48
APNIC Region origin ASes announcing only one prefix:	1206
APNIC Region transit ASes present in the Internet Routing Table:	865
Average APNIC Region AS path length visible:	4.7
Max APNIC Region AS path length visible:	78
Number of APNIC region 32-bit ASNs visible in the Routing Table:	1172
Number of APNIC addresses announced to Internet:	737088832
Equivalent to 43 /8s, 239 /16s and 21 /24s	
Percentage of available APNIC address space announced:	86.1

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
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## Global per AS prefix count summary

ASN	No of nets	/20 equiv	Max Agg	Description
4538	5620	4190	71	China Education and Research
10620	3034	492	244	Telmex Colombia S.A.
4766	2962	11585	932	Korea Telecom
6389	2894	3688	51	BellSouth.net Inc.
17974	2839	903	77	PT Telekomunikasi Indonesia
22773	2838	2956	144	Cox Communications Inc.
7545	2458	336	125	TPG Telecom Limited
28573	2450	2256	111	NET Serviços de Comunicação
18566	2045	379	184	MegaPath Corporation
4755	1909	411	185	TATA Communications formerly
34984	1839	296	355	TELLCOM ILETISIM HIZMETLERI A
20115	1821	1796	479	Charter Communications
7303	1766	1171	241	Telecom Argentina S.A.
7029	1711	2180	363	Windstream Communications Inc
9829	1670	1322	37	National Internet Backbone
4323	1640	1052	411	tw telecom holdings, inc.
6983	1594	867	250	EarthLink, Inc.
4812	1522	2098	110	China Telecom (Group)
20940	1495	580	1104	Akamai International B.V.
30036	1494	311	604	Mediacom Communications Corp

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	/11:90	/12:262
/13:500	/14:1010	/15:1721	/16:13041	/17:7249	/18:12078
/19:25515	/20:36617	/21:37892	/22:55915	/23:48952	/24:279217
/25:1127	/26:1092	/27:704	/28:15	/29:19	/30:11
/31:0	/32:12				

November 2014    ↑

November 2013    ↓

## 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	/10:31	/11:92	/12:254
/13:474	/14:922	/15:1628	/16:12833	/17:6760	/18:11334
/19:23102	/20:32903	/21:35605	/22:50000	/23:43850	/24:250577
/25:875	/26:997	/27:472	/28:51	/29:81	/30:21
/31:0	/32:14				

## Prefixes Smaller than Registry Allocations

ASN	No of nets	Total ann.	Description
18566	2002	2047	MegaPath Corporation
6389	1692	2959	BellSouth.net Inc.
22773	1683	2438	Cox Communications Inc.
30036	1245	1407	Mediacom Communications Corp
8402	1230	1556	OJSC "Vimpelcom"
11492	1175	1215	CABLE ONE, INC.
1785	1166	2208	PaeTec Communications, Inc.
36998	1080	1114	Sudanese Mobile Telephone (ZA
6983	1042	1325	ITC^Deltacom
34984	1038	1709	TELLCOM ILETISIM HIZMETLERI A
22561	1004	1306	CenturyTel Internet Holdings,
10620	999	2853	Telmex Colombia S.A.
31148	962	1018	Freenet Ltd.
28573	859	3410	NET Serviços de Comunicação
7011	896	1129	Frontier Communications of Am
13188	857	1049	TOV "Bank-Inform"
13977	750	775	FAIRPOINT COMMUNICATIONS, INC
4766	726	2947	Korea Telecom
27947	707	875	Telconet S.A
6849	641	824	JSC "Ukrtelecom"

AfriNIC APNIC ARIN LACNIC RIPE NCC

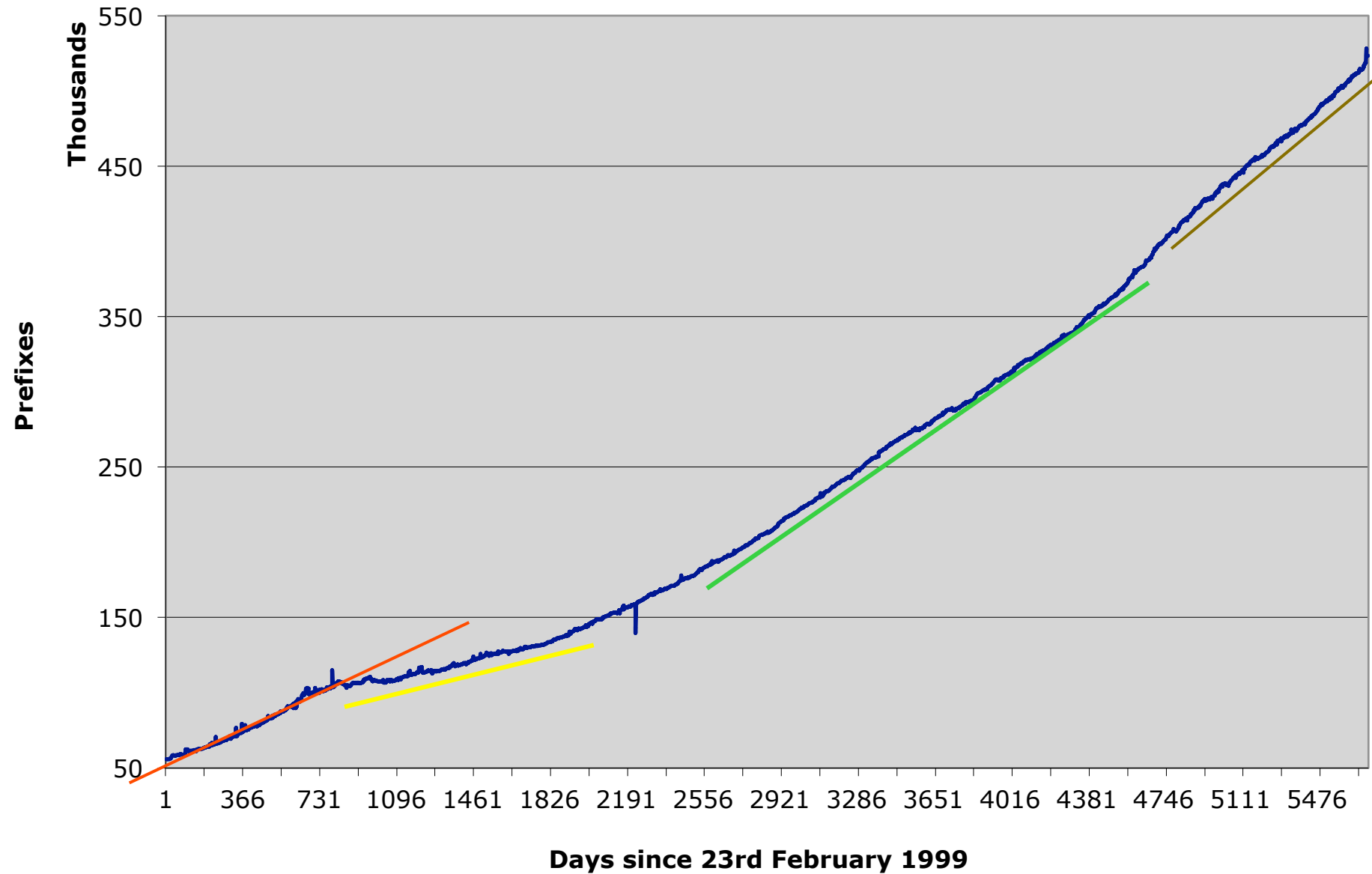
## Prefixes Smaller than Registry Allocations

ASN	No of nets	Total ann.	Description
22773	2056	2838	Cox Communications Inc.
18566	2000	2045	MegaPath Corporation
6389	1674	2894	BellSouth.net Inc.
30036	1340	1494	Mediacom Communications Corp
6983	1278	1594	EarthLink, Inc.
34984	1162	1839	TELLCOM ILETISIM HIZMETLERI A
11492	1161	1214	CABLE ONE, INC.
10620	1074	3034	Telmex Colombia S.A.
8402	1009	1344	OJSC "Vimpelcom"
22561	1006	1315	CenturyTel Internet Holdings,
7029	1002	1711	Windstream Communications Inc
6147	1000	1368	Telefonica del Peru S.A.A.
31148	964	1045	Freenet Ltd.
7011	862	1084	Frontier Communications of Am
13188	851	1030	TOV "Bank-Inform"
13977	776	810	FAIRPOINT COMMUNICATIONS, INC
27738	758	780	Ecuadortelecom S.A.
8452	746	1398	TE-AS
27947	744	916	Telconet S.A
4766	716	2962	Korea Telecom

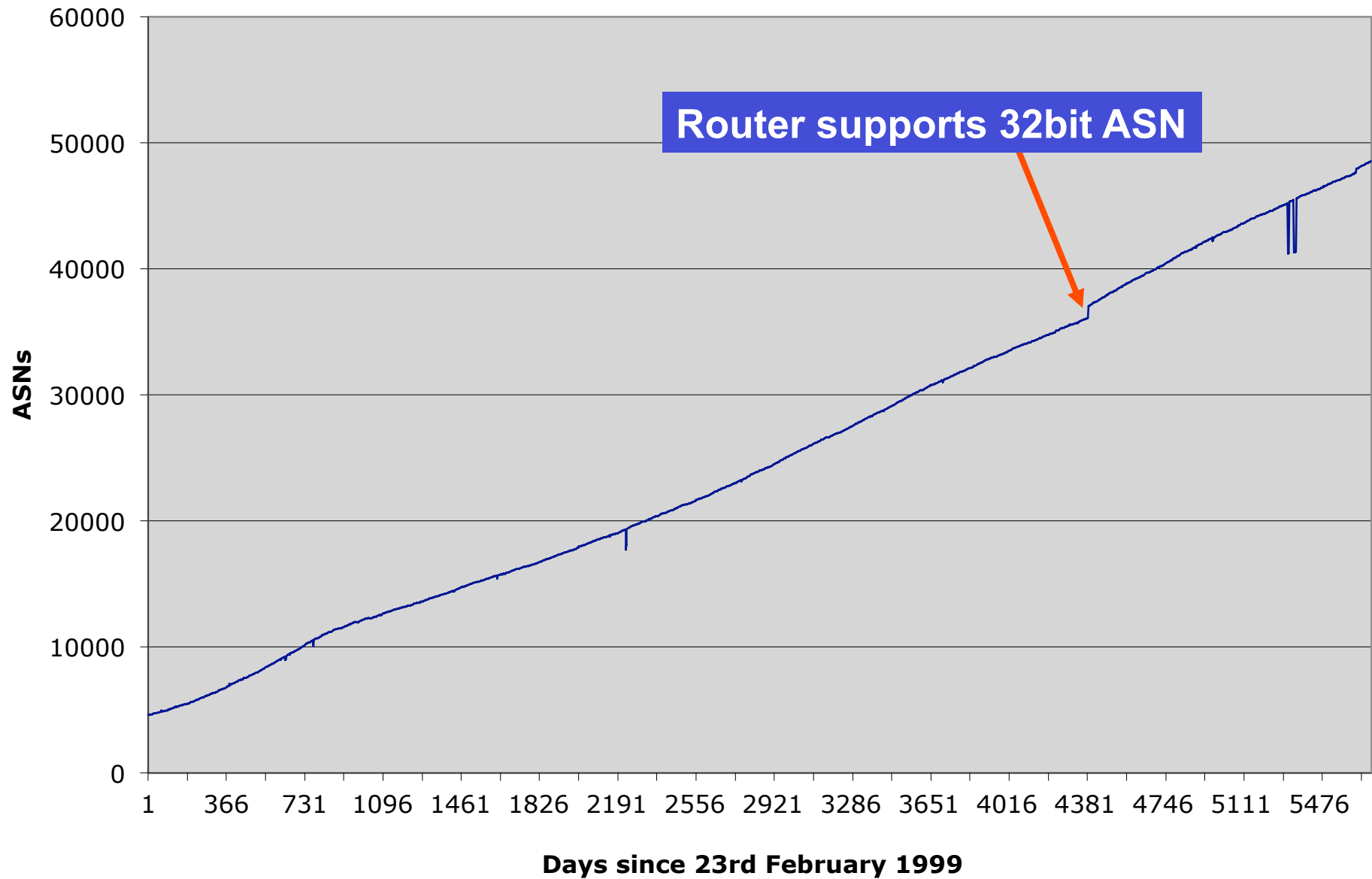
AfriNIC APNIC ARIN LACNIC RIPE NCC



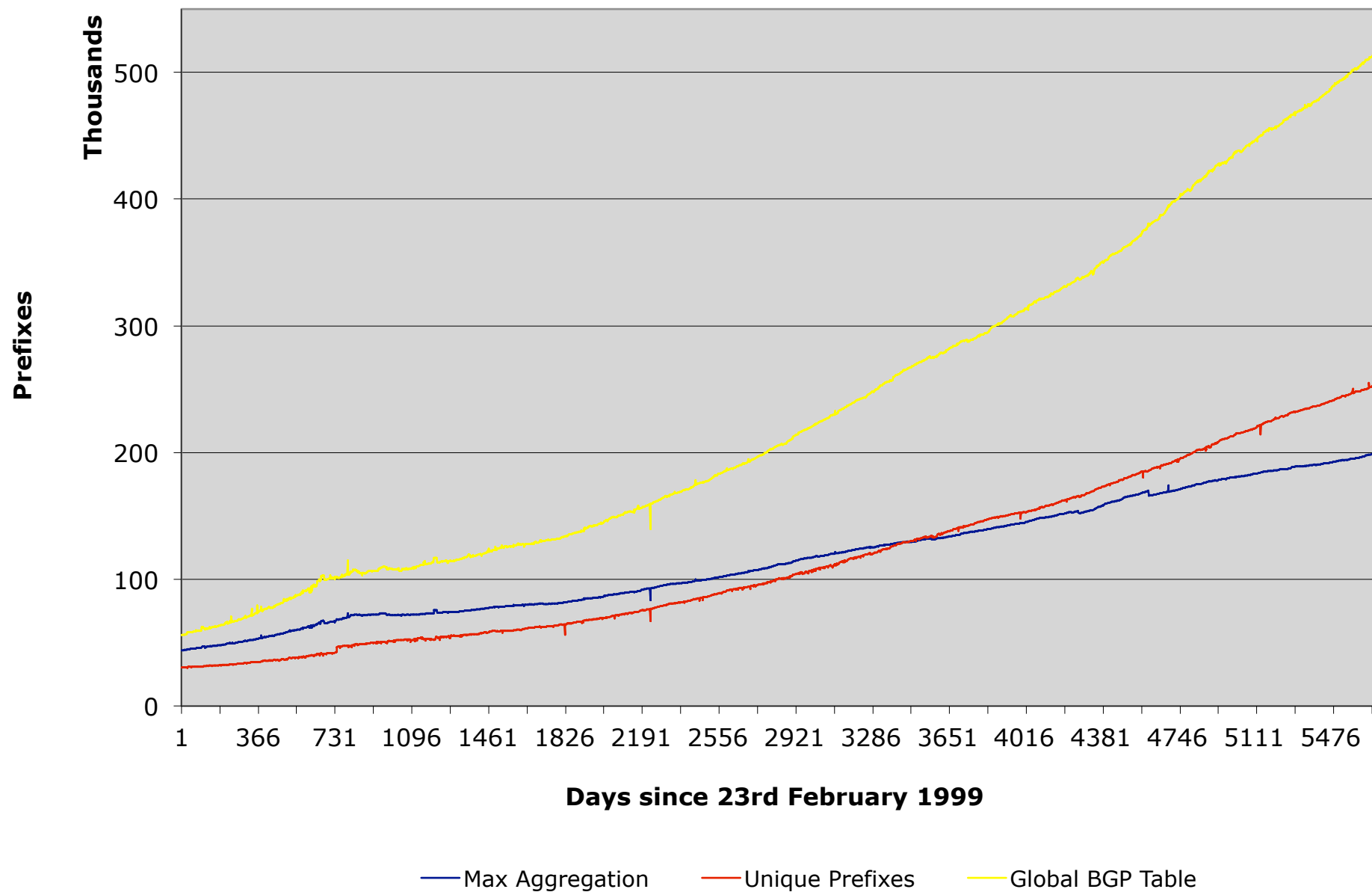
## BGP Routing Table



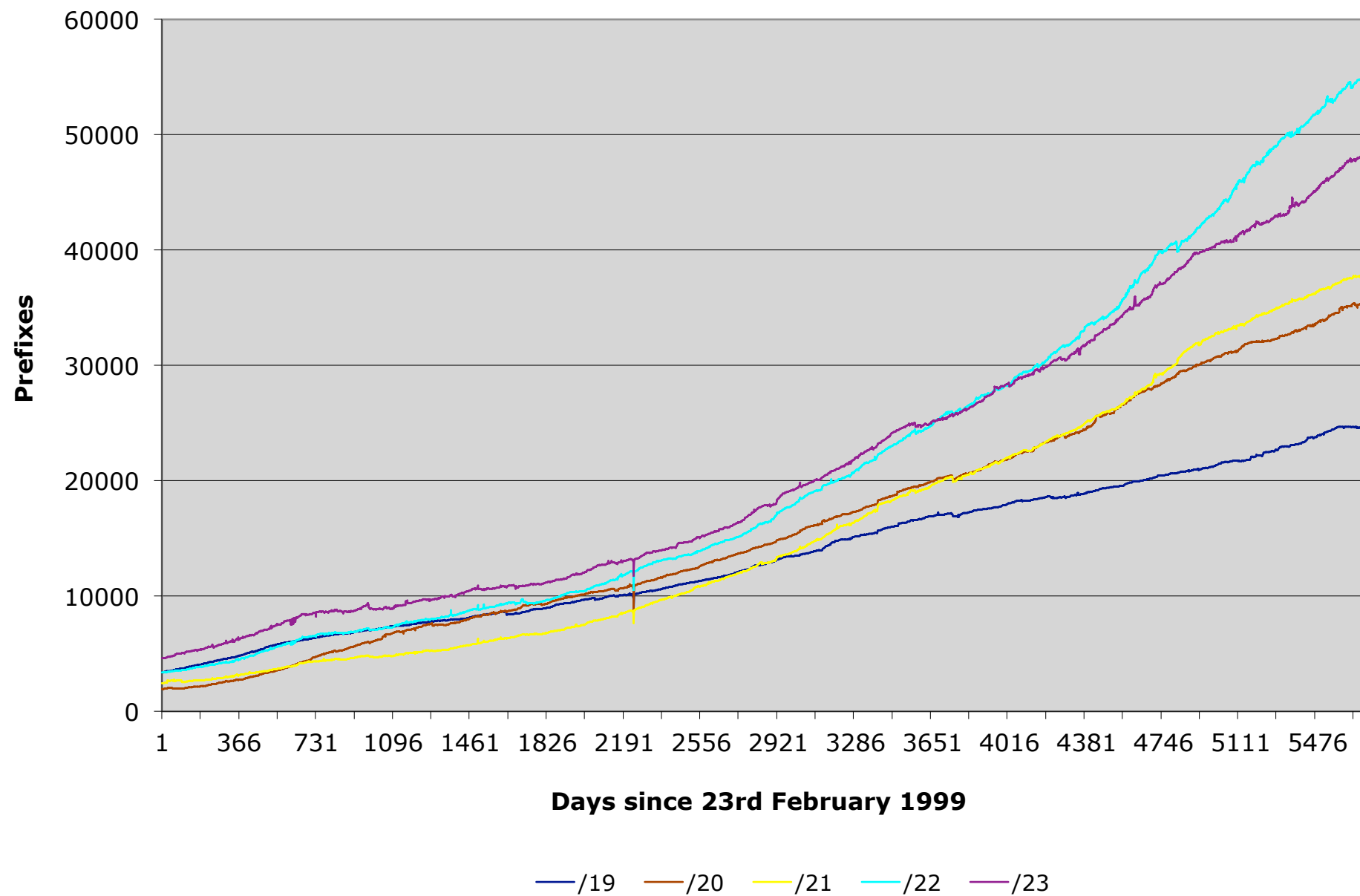
## AS Growth



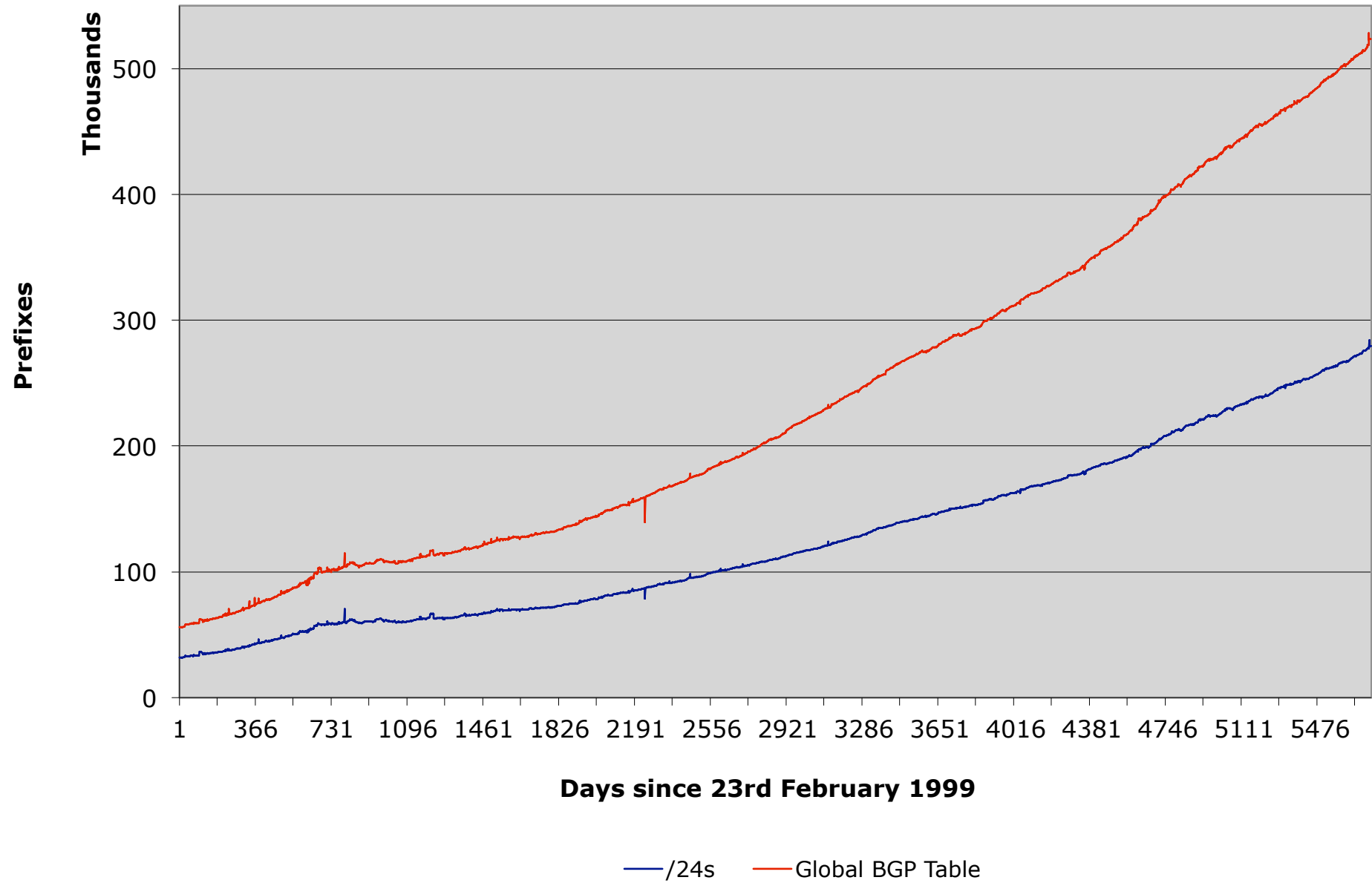
## Max Aggregation vs Unique Prefixes



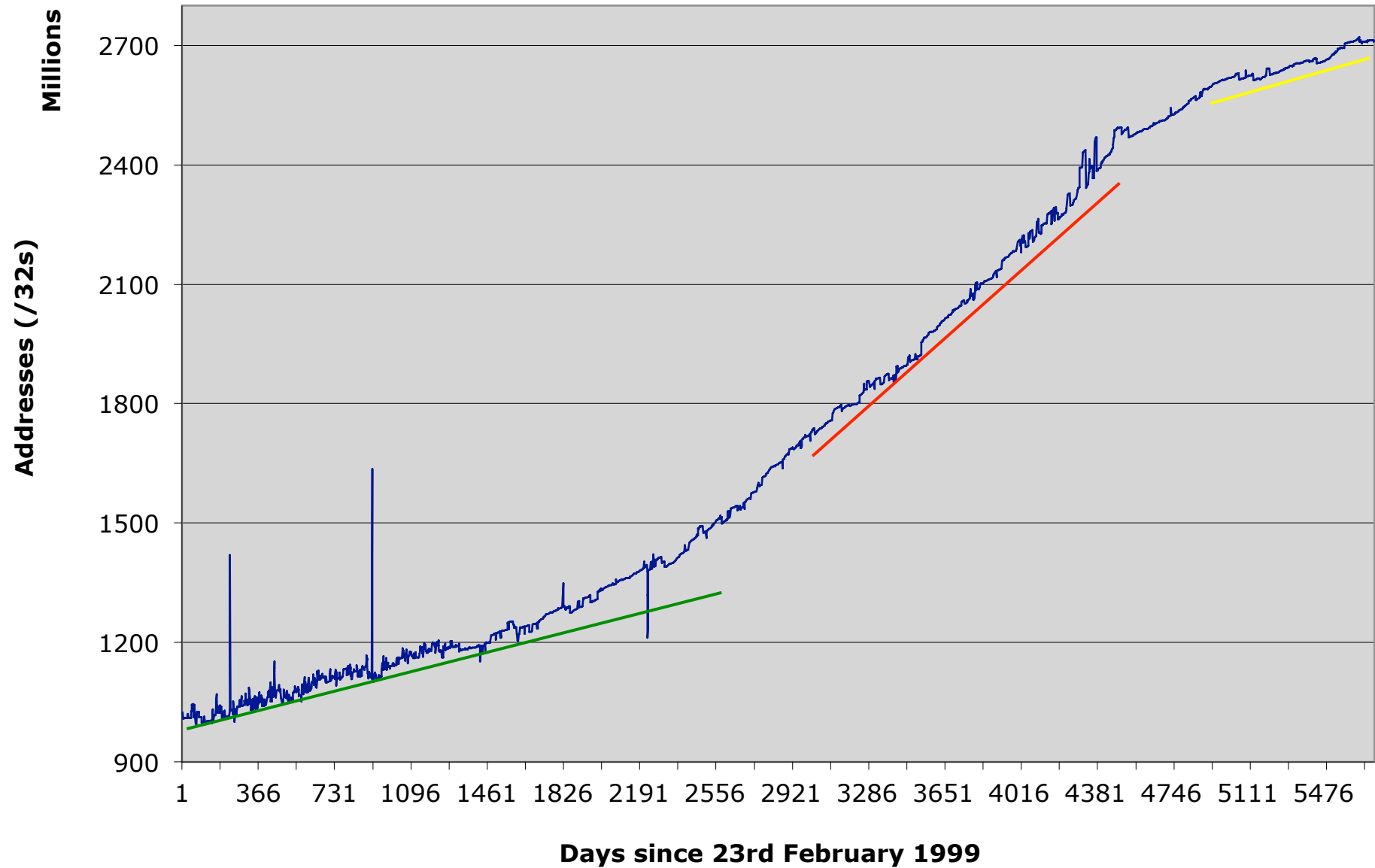
## Prefix sizes announced



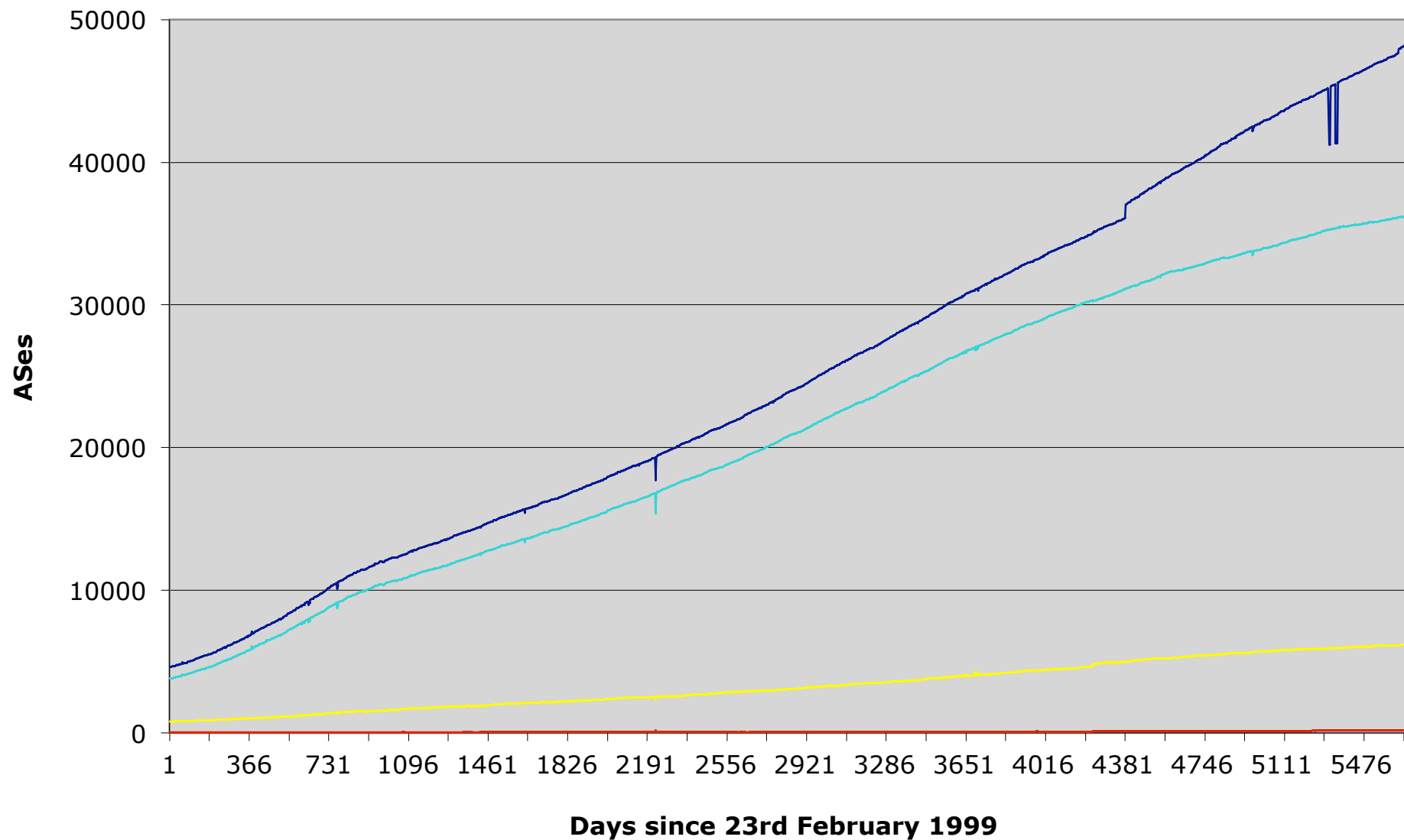
## /24s announced



## Address Space announced



## AS Announcements



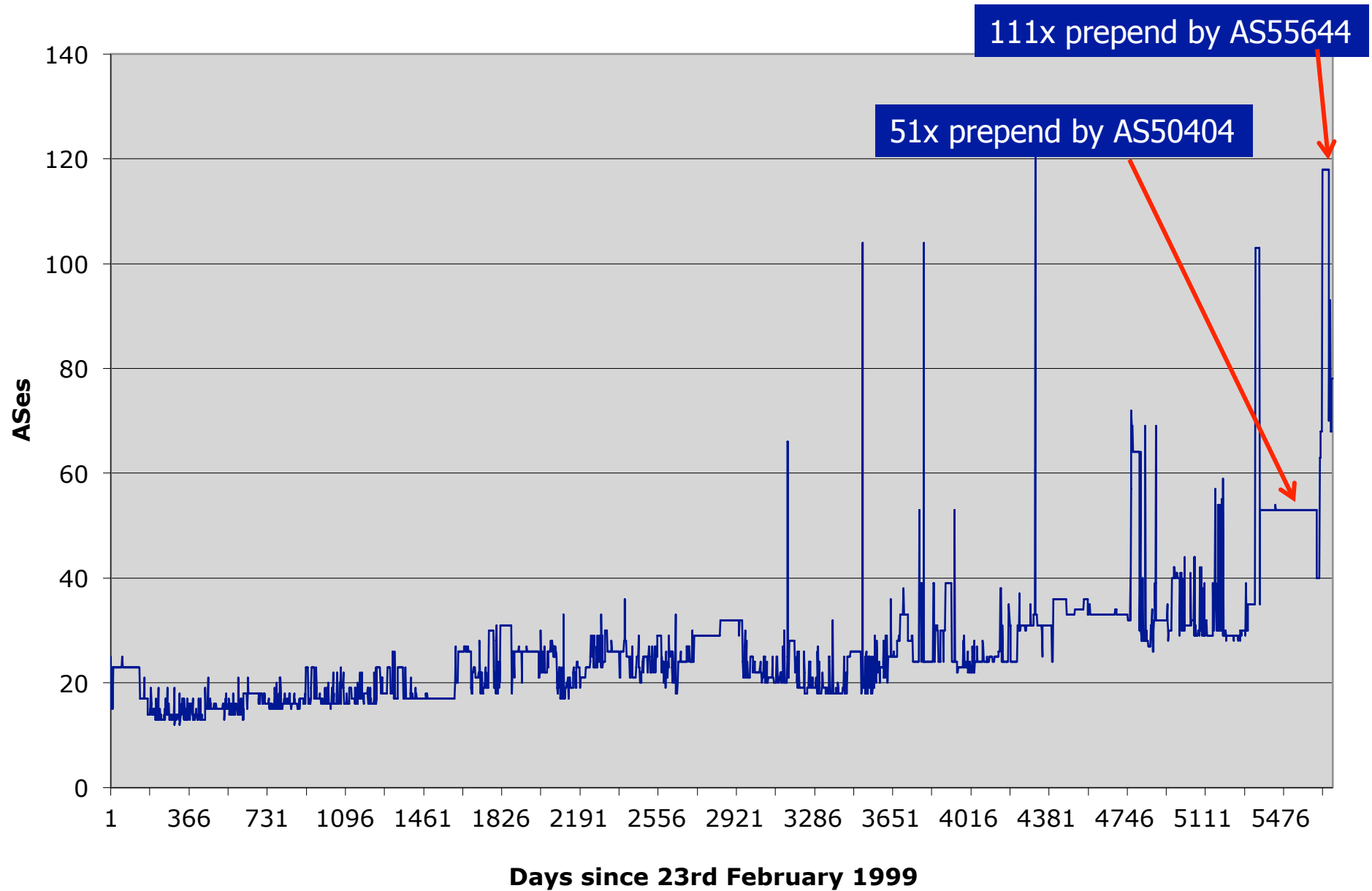
— Total ASNs

— Origin-only ASNs

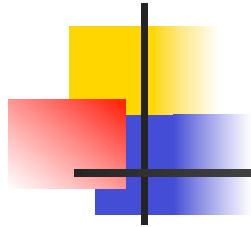
— ASN providing Transit & Origin

— Transit-only ASNs

## Maximum AS Path Length



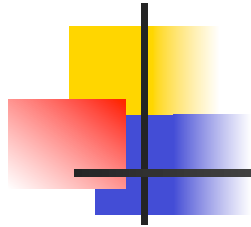




# Looking at Deaggregation

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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”



# November 2014

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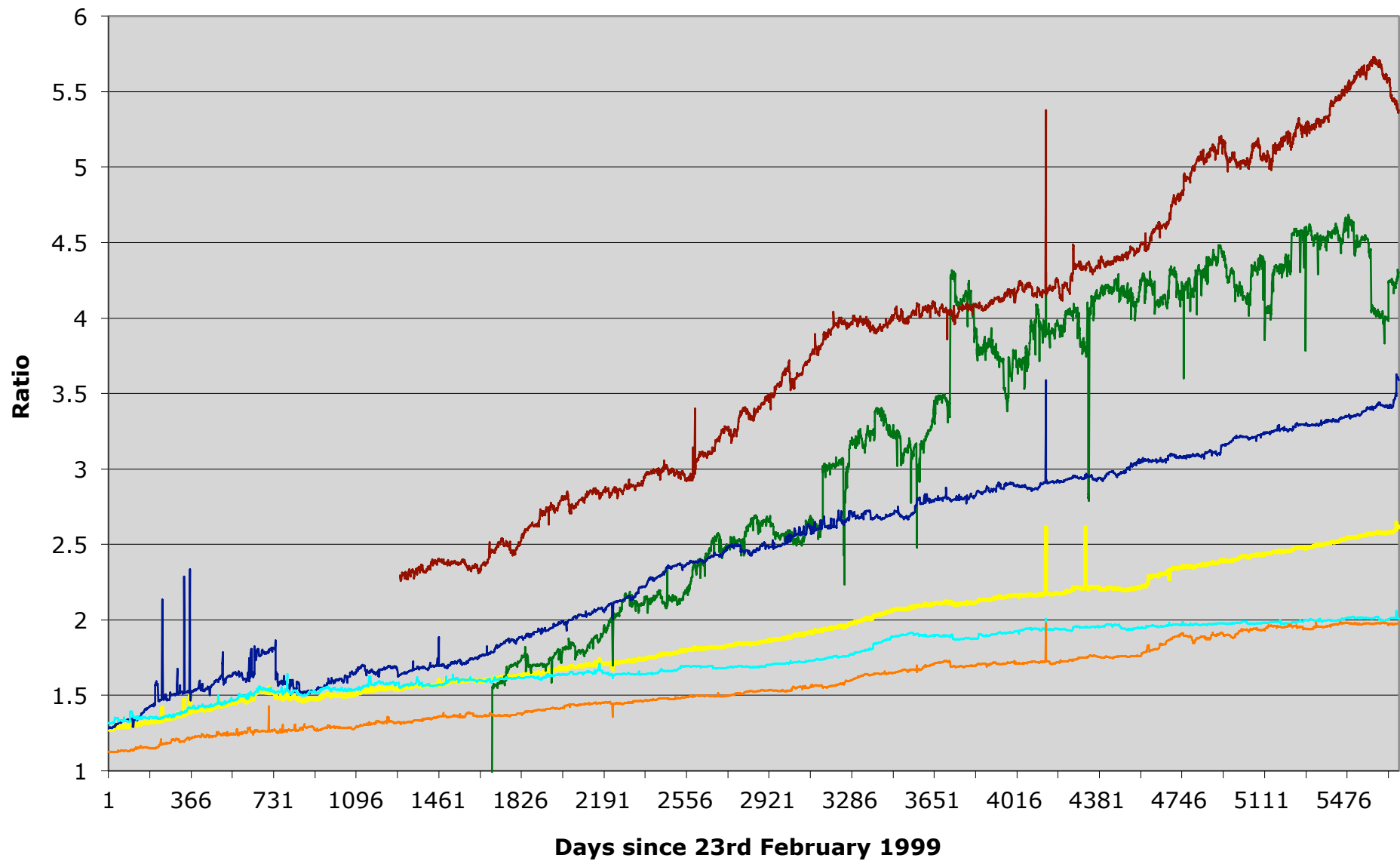
## Total Prefixes

- Global BGP Table
  - 523k prefixes
- Europe & Middle East
  - 126k prefixes
- North America
  - 172k prefixes
- Asia & Pacific
  - 133k prefixes
- Africa
  - 12k prefixes
- Latin America & Caribbean
  - 58k prefixes

## Deaggregation Factor

- Global Average
  - 2.62
- Europe & Middle East
  - 1.98
- North America
  - 2.01
- Asia & Pacific
  - 3.59
- Africa
  - 4.30
- Latin America & Caribbean
  - 5.38

## Deaggregation: RIR Regions vs Global

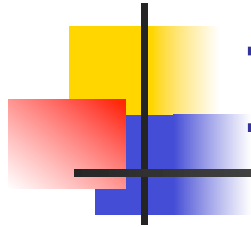


Global AfriNIC APNIC ARIN LACNIC RIPE

## Asia Pacific Aggregation Savings Summary

ASN	No of Nets	Savings	Description
17974	2839	2762	PT Telekomunikasi Indonesia
7545	2458	2333	TPG Telecom Limited
4766	2962	2030	Korea Telecom
4755	1909	1724	TATA Communications formerly
9829	1670	1633	National Internet Backbone
9808	1483	1467	Guangdong Mobile Communicatio
4812	1522	1412	China Telecom (Group)
9498	1315	1221	BHARTI Airtel Ltd.
7552	1176	1164	Viettel Corporation
4788	1103	1048	TM Net, Internet Service Prov
38197	1118	1018	Sun Network (Hong Kong) Limit
4808	1425	998	CNCGROUP IP network China169
24560	1184	993	Bharti Airtel Ltd., Telemedia
4780	1051	977	Digital United Inc.
17488	1053	830	Hathway IP Over Cable Interne
9583	1362	801	Sify Limited
18101	956	761	Reliance Communications Ltd.D
55430	691	671	Starhub Internet Pte Ltd
45528	747	666	Tikona Digital Networks Pvt L
18403	630	615	The Corporation for Financing

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



# Importance of Aggregation

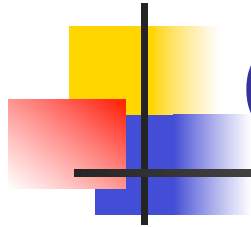
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- Size of routing table
  - Memory is no longer a problem
  - Routers routinely carry over 1 million prefixes
- Convergence of the Routing System
  - This is a problem
  - Bigger table takes longer for CPU to process
  - BGP updates take longer to deal with
  - BGP Instability Report tracks routing system update activity
    - <http://bgpupdates.potaroo.net/instability/bgpupd.html>

bgpupdates.potaroo.net						
The BGP Instability Report						
<div>The BGP Instability Report is updated daily. This report was generated on 16 November 2014 06:32 (UTC+1000)</div>						
50 Most active ASes for the past 7 days						
RANK	ASN	UPDs	%	Prefixes	UPDs/Prefix	AS NAME
1	12897	1621917	29.12%	14	115851.21	HEAGMEDIANET HSE Medianet GmbH,DE
2	14287	266755	4.79%	54	4939.91	TRIAD-TELECOM - Triad Telecom, Inc.,US
3	23752	225075	4.04%	131	1718.13	NPTELECOM-NP-AS Nepal Telecommunications Corporation, Internet Services,NP
4	9829	175244	3.15%	1674	104.69	BSNL-NIB National Internet Backbone,IN
5	48159	50450	0.91%	285	177.02	TIC-AS Telecommunication Infrastructure Company,IR
6	17974	28082	0.50%	2849	9.86	TELKOMNET-AS2-AP PT Telekomunikasi Indonesia,ID
7	28642	25415	0.46%	34	747.50	Contato Internet Ltda EPP,BR
8	8402	24337	0.44%	1469	16.57	CORBINA-AS OJSC "Vimpelcom",RU
9	14840	24302	0.44%	34	714.76	COMMCORP COMUNICACOES LTDA,BR
10	3	24039	0.43%	3	8013.00	MIT-GATEWAYS - Massachusetts Institute of Technology,US
11	53249	24038	0.43%	2	12019.00	LAWA-AS - Los Angeles World Airport,US
12	23342	22124	0.40%	40	553.10	UNITEDLAYER - Unitedlayer, Inc.,US
13	25003	20083	0.36%	38	528.50	INTERNET_BINAT Internet Binat Ltd,IL
14	3816	19924	0.36%	903	22.06	COLOMBIA TELECOMUNICACIONES S.A. ESP,CO
15	27738	19280	0.35%	780	24.72	Ecuadortelecom S.A.,EC
16	60725	17462	0.31%	17	1027.18	O3B-AS O3b Limited,JE
17	23693	17124	0.31%	143	119.75	TELKOMSEL-ASN-ID PT. Telekomunikasi Selular,ID
18	12066	16942	0.30%	428	39.58	TRICOM,DO
19	52828	15860	0.28%	30	528.67	Netpal Internet Palmares Ltda.,BR
20	4780	14393	0.26%	1059	13.59	SEEDNET Digital United Inc.,TW
21	7029	14393	0.26%	2282	6.31	WINDSTREAM - Windstream Communications Inc,US
22	42337	14360	0.26%	154	93.25	RESPINA-AS Respina Networks & Beyond PJSC,IR
23	28573	14015	0.25%	2547	5.50	NET Serviços de Comunicação S.A.,BR
24	13188	13589	0.24%	1030	13.19	BANKINFORM-AS CONTENT DELIVERY NETWORK LTD,UA
25	14420	13508	0.24%	597	22.63	CORPORACION NACIONAL DE TELECOMUNICACIONES - CNT E,EC







# 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?