

Internet IPv4 Routing Table Analysis Update



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SANOG 23

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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 12 January 2014

BGP routing table entries examined:	477838
Prefixes after maximum aggregation:	190409
Deaggregation factor:	2.51
Unique aggregates announced to Internet:	236754
Total ASes present in the Internet Routing Table:	45878
Prefixes per ASN:	10.42
Origin-only ASes present in the Internet Routing Table:	35490
Origin ASes announcing only one prefix:	16276
Transit ASes present in the Internet Routing Table:	5998
Transit-only ASes present in the Internet Routing Table:	172
Average AS path length visible in the Internet Routing Table:	4.6
Max AS path length visible:	53
Max AS path prepend of ASN (50404)	51
Prefixes from unregistered ASNs in the Routing Table:	2677
Unregistered ASNs in the Routing Table:	632
Number of 32-bit ASNs allocated by the RIRs:	5670
Number of 32-bit ASNs visible in the Routing Table:	4390
Prefixes from 32-bit ASNs in the Routing Table:	13921
Number of bogon 32-bit ASNs visible in the Routing Table:	1
Special use prefixes present in the Routing Table:	0
Prefixes being announced from unallocated address space:	1830
Number of addresses announced to Internet:	2659567100
Equivalent to 158 /8s, 133 /16s and 197 /24s	
Percentage of available address space announced:	71.8
Percentage of allocated address space announced:	71.8
Percentage of available address space allocated:	100.0
Percentage of address space in use by end-sites:	95.4
Total number of prefixes smaller than registry allocations:	166261

APNIC Region

Prefixes being announced by APNIC Region ASes:	113525
Total APNIC prefixes after maximum aggregation:	34201
APNIC Deaggregation factor:	3.32
Prefixes being announced from the APNIC address blocks:	115923
Unique aggregates announced from the APNIC address blocks:	48504
APNIC Region origin ASes present in the Internet Routing Table:	4867
APNIC Prefixes per ASN:	23.82
APNIC Region origin ASes announcing only one prefix:	1210
APNIC Region transit ASes present in the Internet Routing Table:	833
Average APNIC Region AS path length visible:	4.6
Max APNIC Region AS path length visible:	28
Number of APNIC region 32-bit ASNs visible in the Routing Table:	801
Number of APNIC addresses announced to Internet:	730204608
Equivalent to 43 /8s, 134 /16s and 9 /24s	
Percentage of available APNIC address space announced:	85.3

APNIC AS Blocks 4608-4864, 7467-7722, 9216-10239, 17408-18431
(pre-ERX allocations) 23552-24575, 37888-38911, 45056-46079, 55296-56319,
 58368-59391, 63488-63999, 131072-133631

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
28573	3410	1837	98	NET Serviços de Comunicação
6389	3029	3688	53	BellSouth.net Inc.
4766	2944	11558	953	Korea Telecom
17974	2737	902	88	PT Telekomunikasi Indonesia
10620	2696	436	203	Telmex Colombia S.A.
22773	2323	2940	139	Cox Communications Inc.
1785	2147	687	132	PaeTec Communications, Inc.
7545	2127	319	111	TPG Telecom Limited
18566	2049	379	178	MegaPath Corporation
8402	1888	544	16	OJSC "Vimpelcom"
4755	1811	392	193	TATA Communications formerly
36998	1805	112	5	Sudanese Mobile Telephone (ZA
18881	1795	908	20	Global Village Telecom
7303	1743	1163	230	Telecom Argentina S.A.
20115	1681	1665	588	Charter Communications
4323	1628	1081	410	tw telecom holdings, inc.
9829	1574	1266	43	National Internet Backbone
701	1506	11159	775	MCI Communications Services,
8151	1378	2865	425	Uninet S.A. de C.V.
30036	1375	296	569	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	/9:11	/10:30	/11:92	/12:254
/13:475	/14:942	/15:1638	/16:12854	/17:6812	/18:11445
/19:23355	/20:33243	/21:35877	/22:50886	/23:44202	/24:253400
/25:791	/26:947	/27:428	/28:40	/29:58	/30:27
/31:0	/32:15				

January 2014 ↑

January 2013 ↓

Number of prefixes announced by prefix length

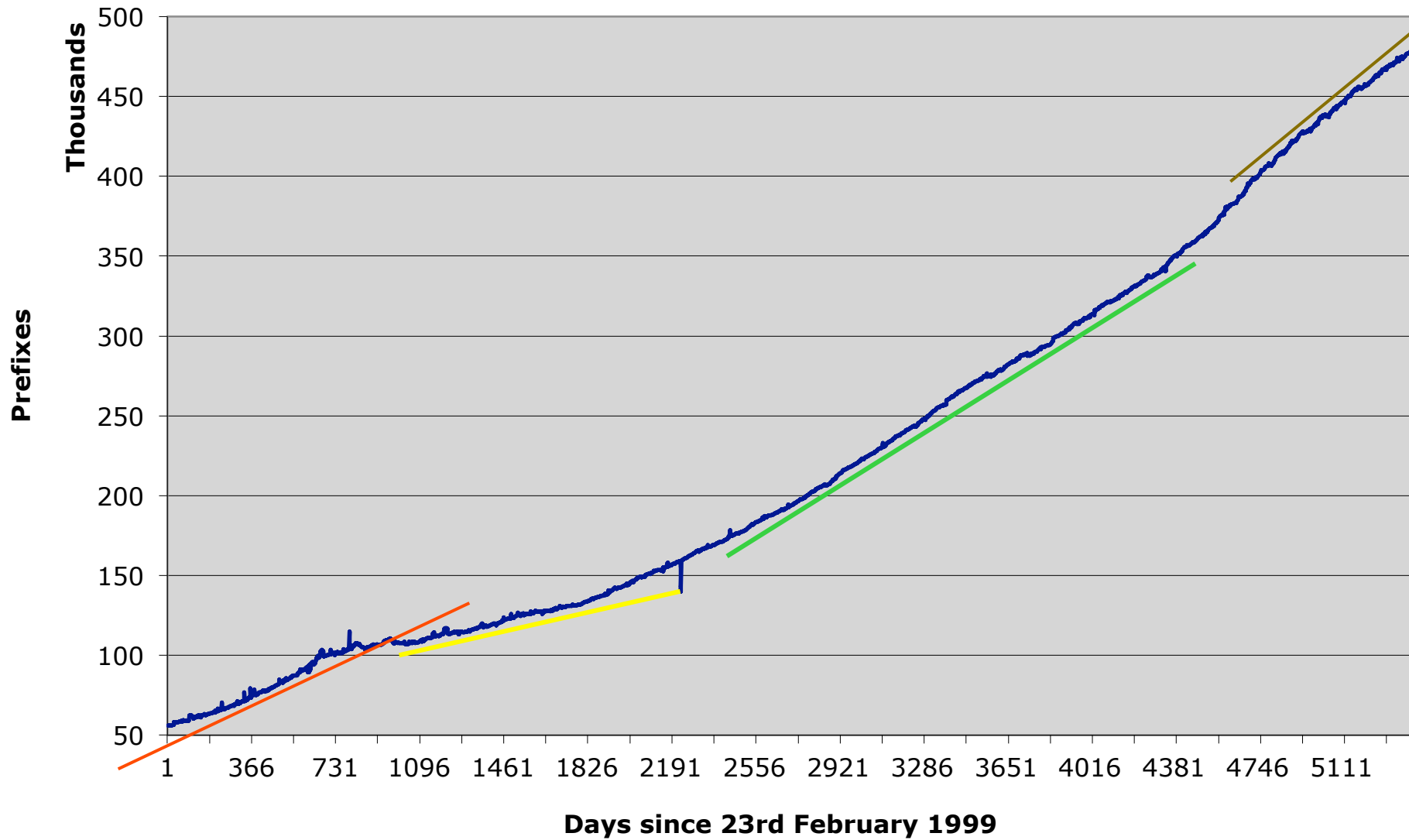
/1:0	/2:0	/3:0	/4:0	/5:0	/6:0
/7:0	/8:18	/9:13	/10:29	/11:87	/12:245
/13:478	/14:860	/15:1548	/16:12501	/17:6586	/18:10934
/19:21636	/20:31125	/21:33155	/22:44421	/23:40713	/24:229361
/25:1316	/26:1696	/27:872	/28:178	/29:74	/30:17
/31:0	/32:21				

Prefixes Smaller than Registry Allocations

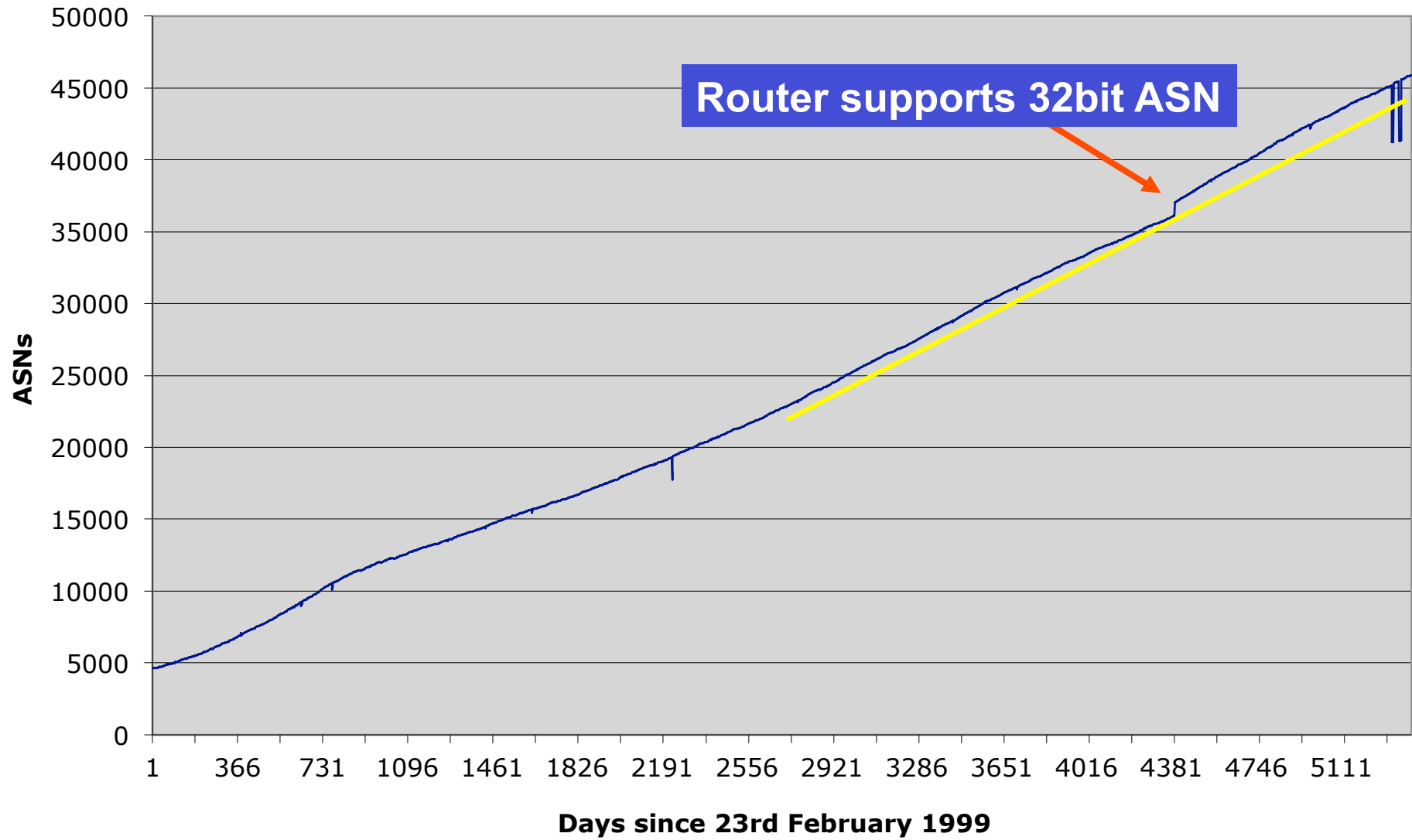
ASN	No of nets	Total ann.	Description
18566	2004	2049	MegaPath Corporation
36998	1771	1805	Sudanese Mobile Telephone (ZA
6389	1699	3029	BellSouth.net Inc.
8402	1577	1888	OJSC "Vimpelcom"
22773	1566	2323	Cox Communications Inc.
30036	1215	1375	Mediacom Communications Corp
1785	1162	2147	PaeTec Communications, Inc.
11492	1157	1194	CABLE ONE, INC.
6983	1036	1295	ITC^Deltacom
22561	979	1258	CenturyTel Internet Holdings,
31148	957	1013	Freenet Ltd.
10620	941	2696	Telmex Colombia S.A.
7011	933	1172	Frontier Communications of Am
34984	928	1366	TELLCOM ILETISIM HIZMETLERI A
28573	859	3410	NET Serviços de Comunicação
13188	848	1036	TOV "Bank-Inform"
13977	828	848	FAIRPOINT COMMUNICATIONS, INC
4766	786	2944	Korea Telecom
35908	745	882	Krypt Technologies
27947	669	834	Telconet S.A

AfriNIC APNIC ARIN LACNIC RIPE NCC

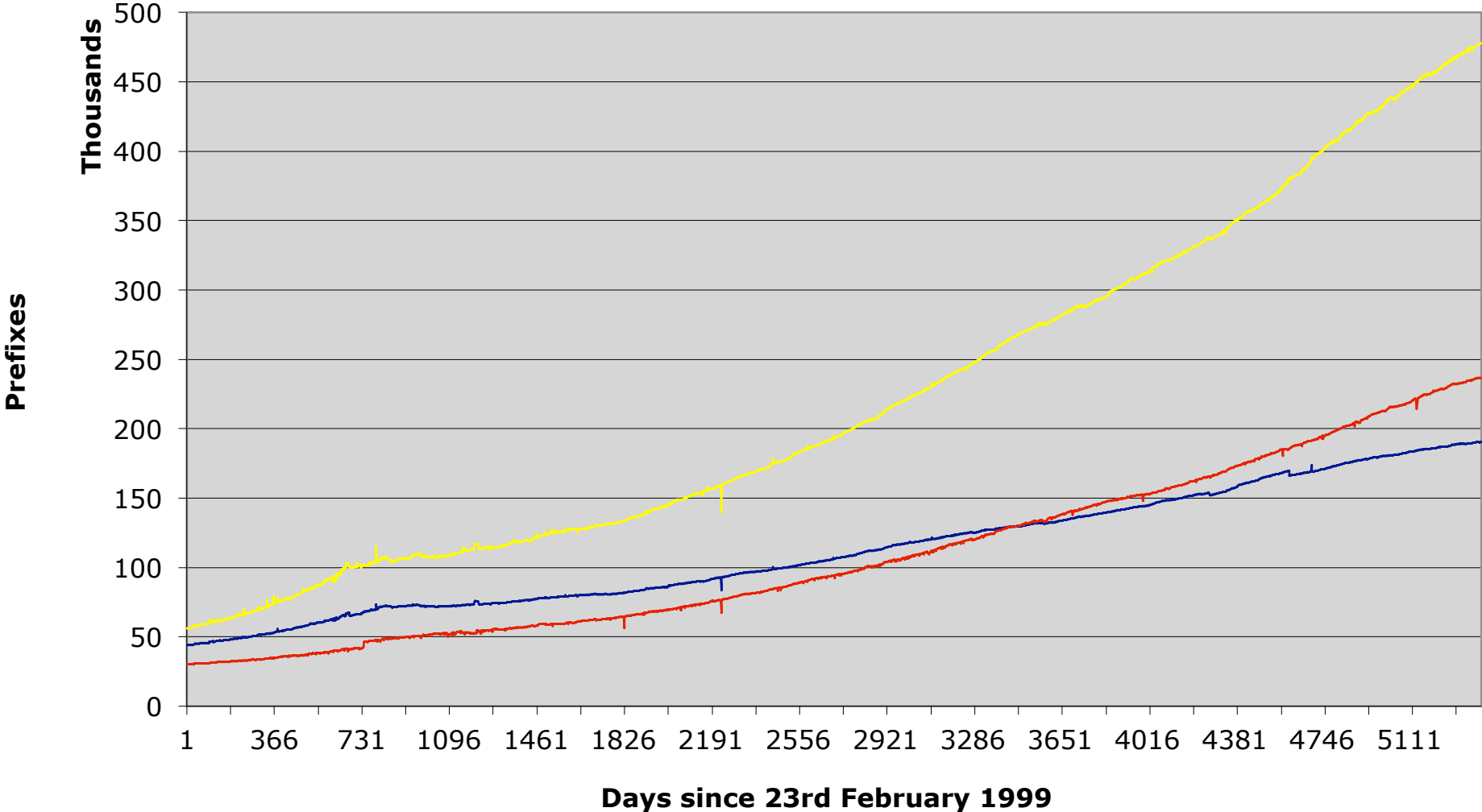
BGP Routing Table



AS Growth

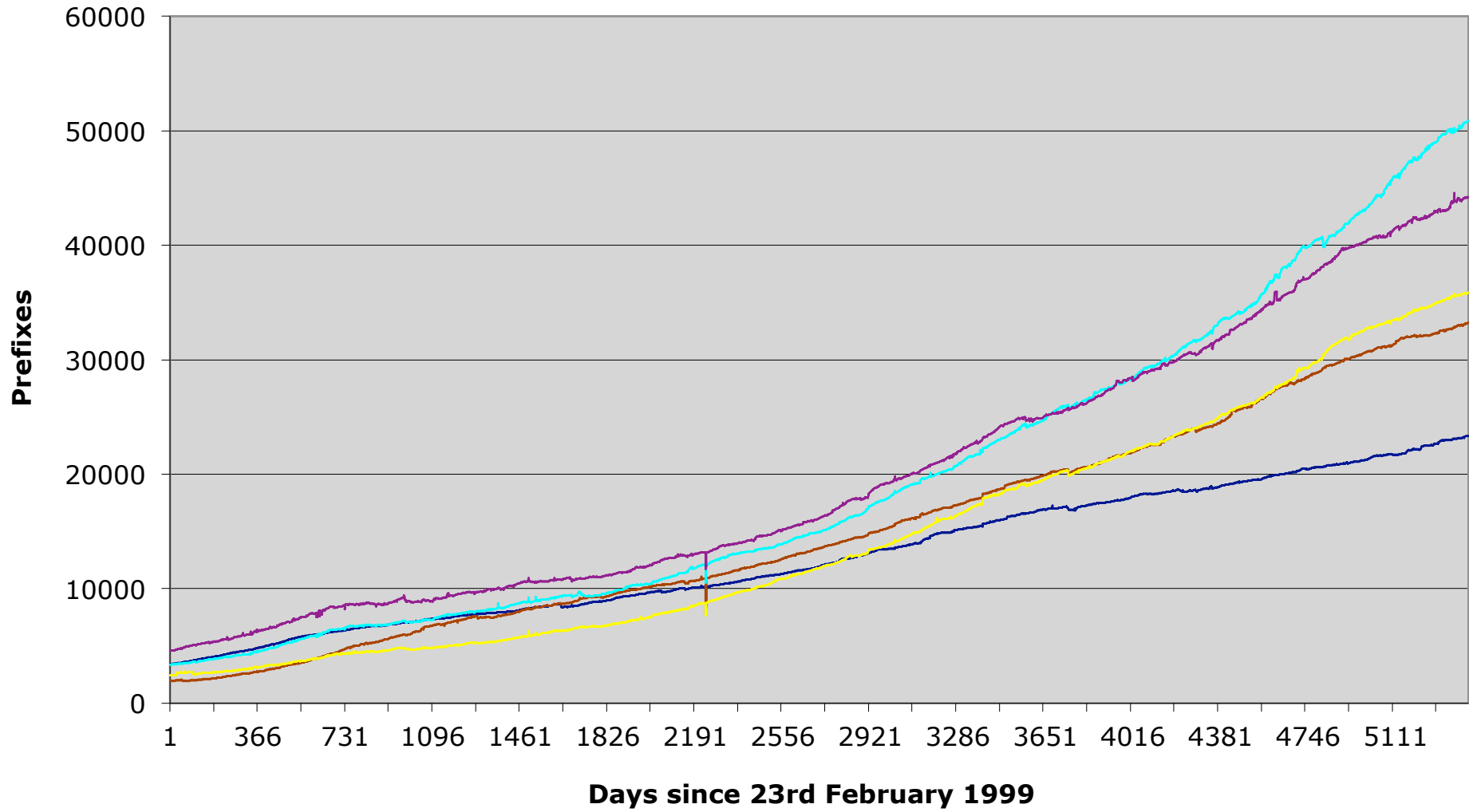


Max Aggregation vs Unique Prefixes



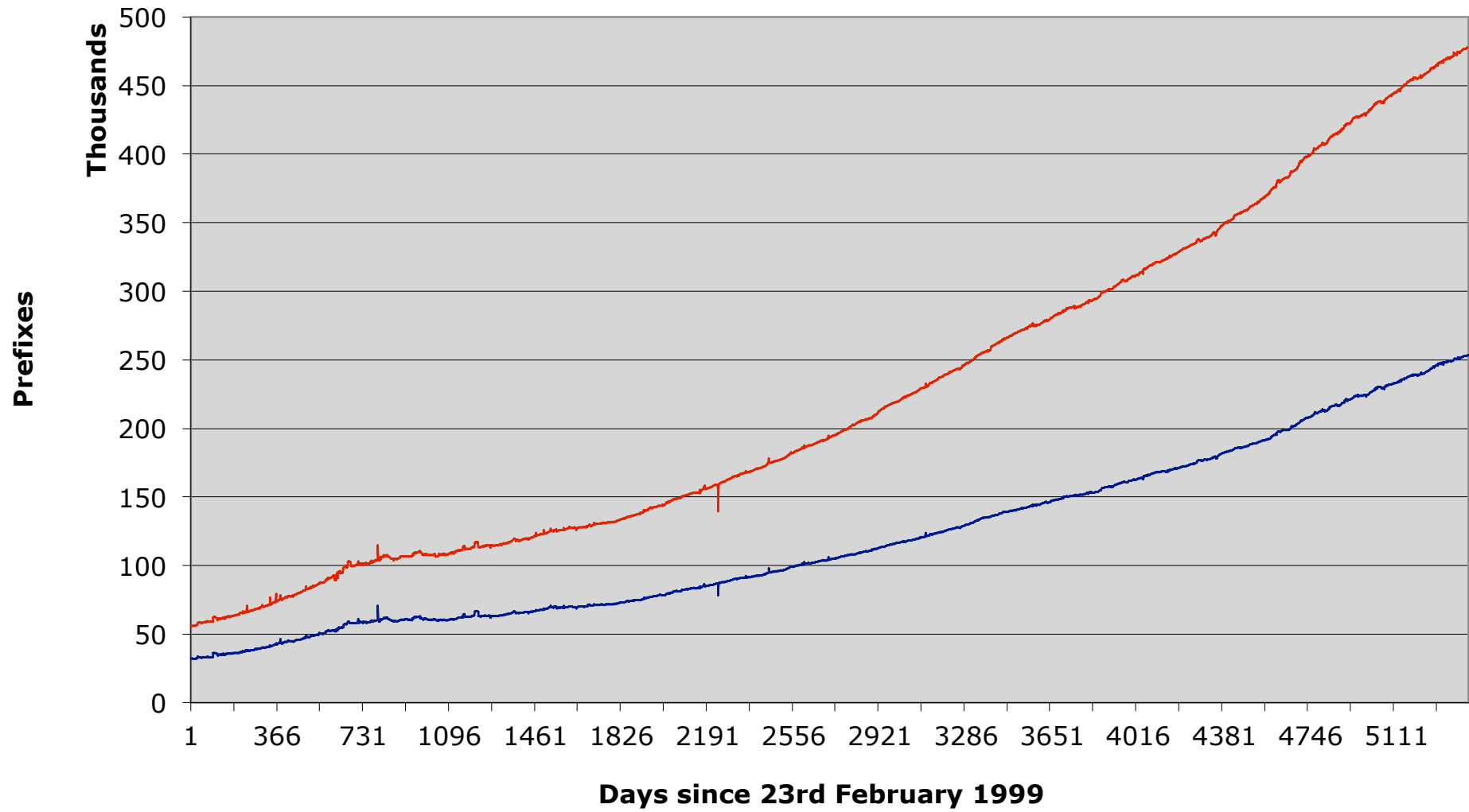
— Max Aggregation — Unique Prefixes — Global BGP Table

Prefix sizes announced



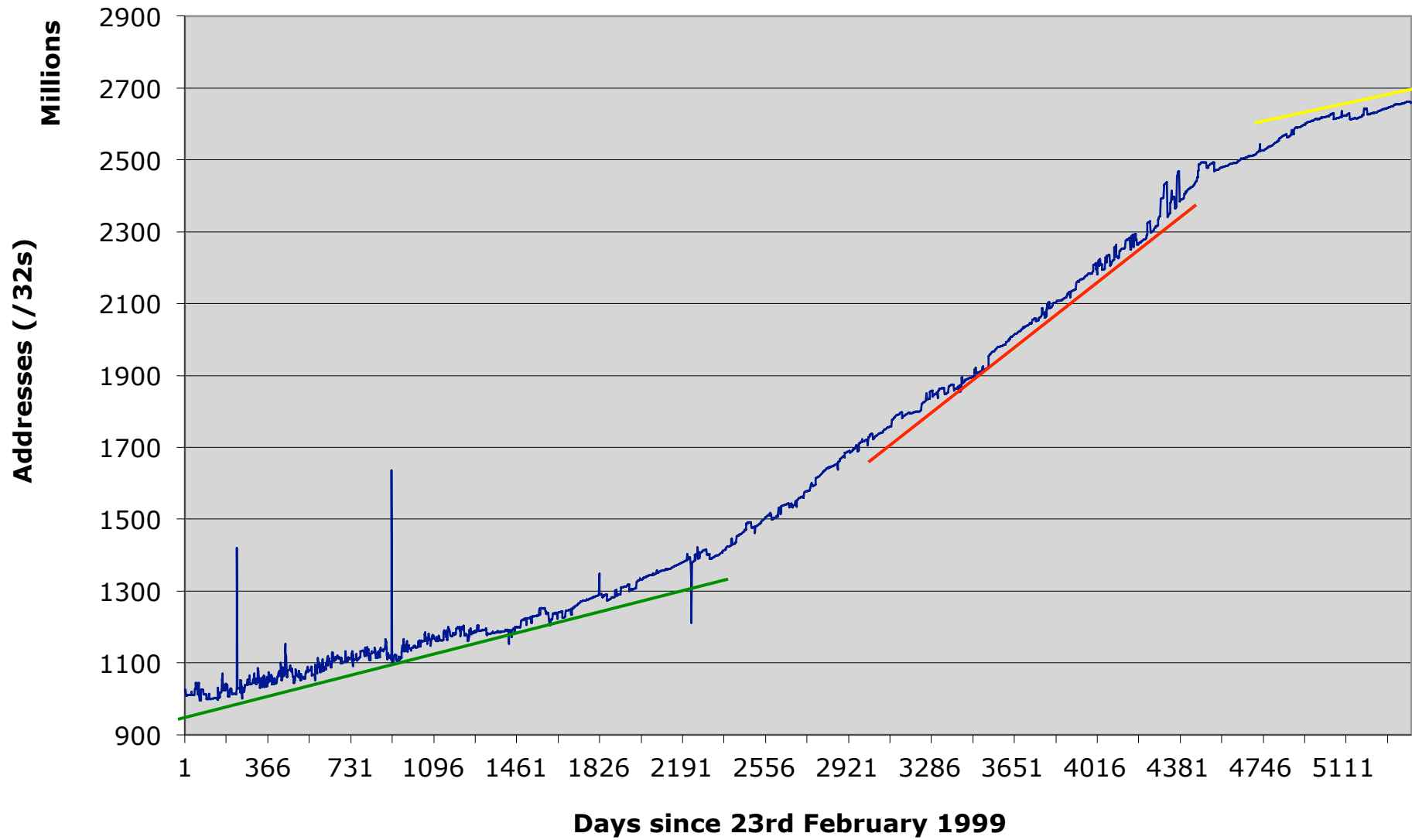
— /19 — /20 — /21 — /22 — /23

/24s announced

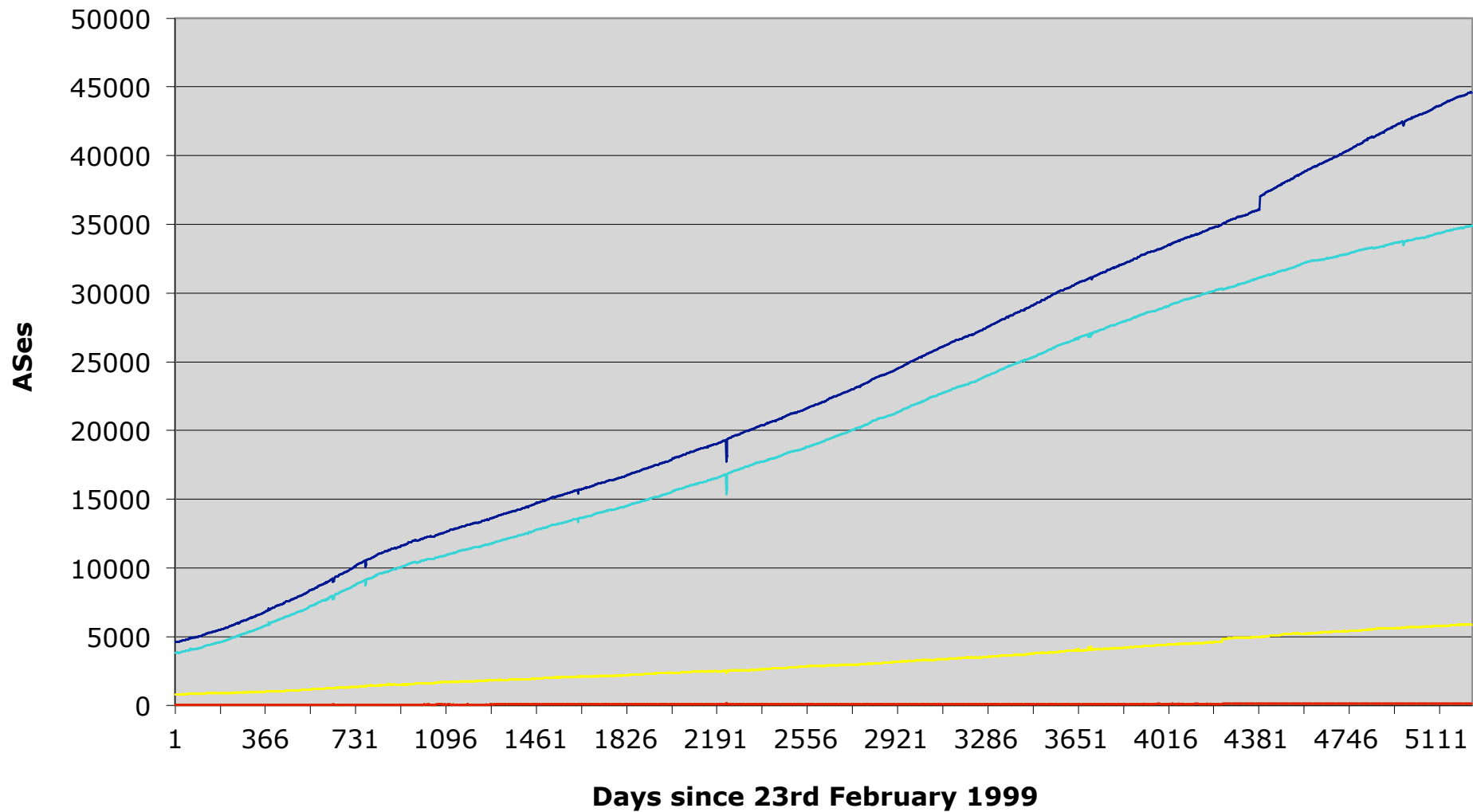


— /24s — Global BGP Table

Address Space announced



AS Announcements



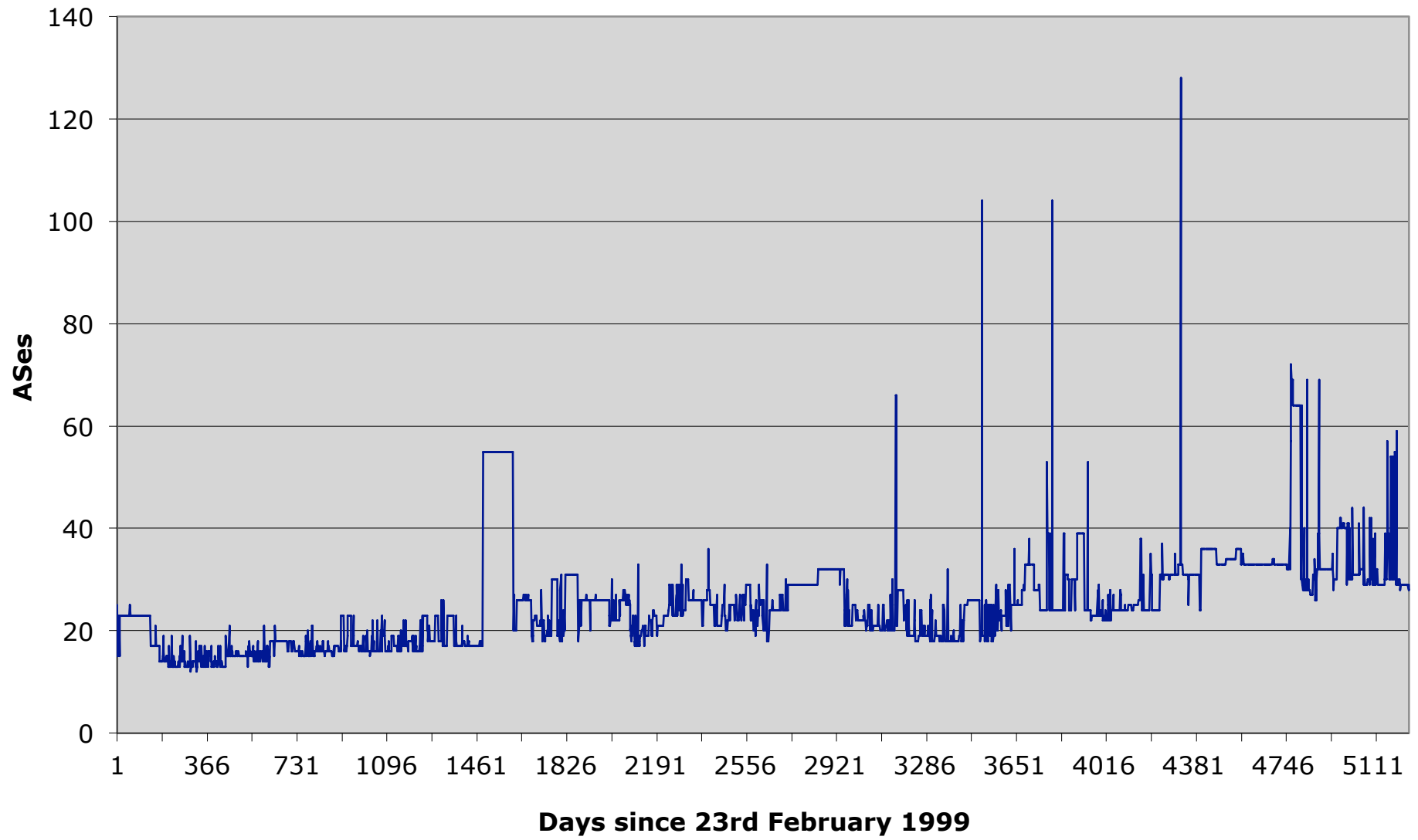
— Total ASNs

— Origin-only ASNs

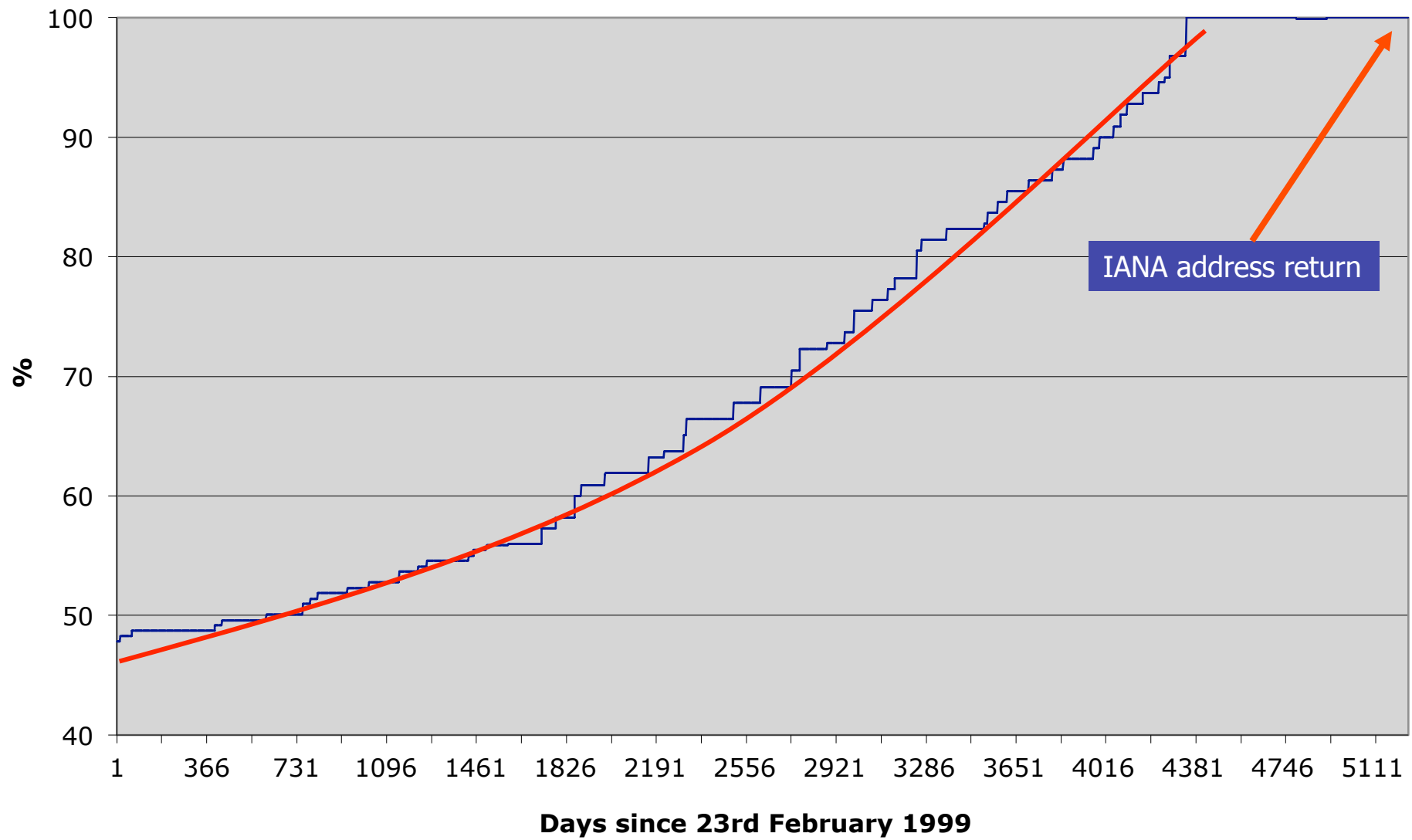
— ASN providing Transit & Origin

— Transit-only ASNs

Maximum AS Path Length



Growth in IPv4 Address Space Allocations





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”



January 2014

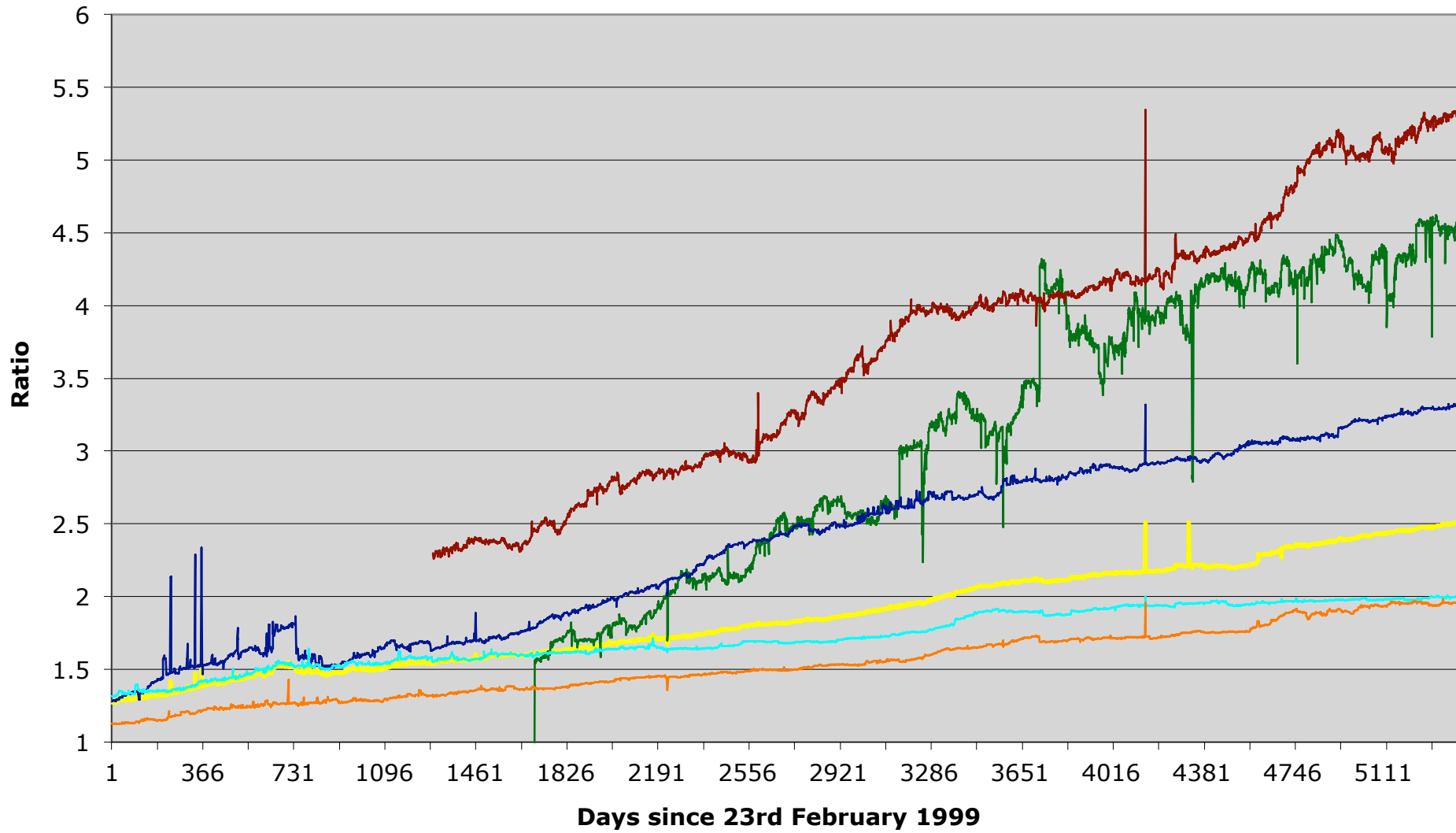
Total Prefixes

- Global BGP Table
 - 478k prefixes
- Europe & Middle East
 - 120k prefixes
- North America
 - 164k prefixes
- Asia & Pacific
 - 114k prefixes
- Africa
 - 12k prefixes
- Latin America & Caribbean
 - 54k prefixes

Deaggregation Factor

- Global Average
 - 2.51
- Europe & Middle East
 - 1.96
- North America
 - 2.00
- Asia & Pacific
 - 3.32
- Africa
 - 4.56
- Latin America & Caribbean
 - 5.34

Deaggregation: RIR Regions vs Global



Global AfriNIC APNIC ARIN LACNIC RIPE

Asia Pacific Aggregation Savings Summary

ASN	No of Nets	Savings	Description
17974	2737	2649	PT Telekomunikasi Indonesia
7545	2127	2016	TPG Telecom Limited
4766	2944	1991	Korea Telecom
4755	1811	1618	TATA Communications formerly
9829	1574	1531	National Internet Backbone
7552	1234	1221	Viettel Corporation
9498	1236	1165	BHARTI Airtel Ltd.
4780	1014	942	Digital United Inc.
24560	1089	922	Bharti Airtel Ltd., Telemedia
9808	892	879	Guangdong Mobile Communicatio
4788	916	866	TM Net, Internet Service Prov
18101	984	803	Reliance Communications Ltd.D
4808	1146	801	CNCGROUP IP network China169
9583	1294	759	Sify Limited
45528	718	645	Tikona Digital Networks Pvt L
17676	775	605	Softbank BB Corp.
18403	602	588	The Corporation for Financing
17623	635	580	China Unicom Shenzen network
55430	570	554	Starhub Internet Pte Ltd
17488	796	529	Hathway IP Over Cable Interne

<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 11 January 2014 06:17 (UTC+1000)

50 Most active ASes for the past 7 days

RANK	ASN	UPDs	%	Prefixes	UPDs/Prefix	AS NAME
1	9829	52564	2.86%	1563	33.63	BSNL-NIB National Internet Backbone
2	4766	51980	2.83%	2946	17.64	KIXS-AS-KR Korea Telecom
3	3816	43341	2.36%	767	56.51	COLOMBIA TELECOMUNICACIONES S.A. ESP
4	8402	40335	2.20%	1995	20.22	CORBINA-AS OJSC "Vimpelcom"
5	14287	35253	1.92%	54	652.83	TRIAD-TELECOM - Triad Telecom, Inc.
6	4323	30619	1.67%	2949	10.38	TWTC - tw telecom holdings, inc.
7	701	29548	1.61%	8623	3.43	UUNET - MCI Communications Services, Inc. d/b/a Verizon Business
8	7029	22867	1.25%	4475	5.11	WINDSTREAM - Windstream Communications Inc
9	13118	20964	1.14%	44	476.45	ASN-YARTELECOM OJSC Rostelecom
10	4775	18599	1.01%	130	143.07	GLOBE-TELECOM-AS Globe Telecoms
11	7552	18089	0.99%	1541	11.74	VIETEL-AS-AP Viettel Corporation
12	41691	16864	0.92%	36	468.44	SUMTEL-AS-RIPE Summa Telecom LLC
13	4538	16169	0.88%	541	29.89	ERX-CERNET-BKB China Education and Research Network Center
14	45899	13866	0.76%	402	34.49	VNPT-AS-VN VNPT Corp
15	59217	13537	0.74%	1	13537.00	AZONNELIMITED-AS-AP Azonne Limited
16	17557	11875	0.65%	122	97.34	PKTELECOM-AS-PK Pakistan Telecommunication Company Limited
17	11976	10996	0.60%	204	53.90	FIDN - Fidelity Communication International Inc.
18	6629	10990	0.60%	68	161.62	NOAA-AS - NOAA
19	1221	10766	0.59%	671	16.04	ASN-TELSTRA Telstra Pty Ltd
20	64777	9985	0.54%	6928	1.44	-Private Use AS-
21	11054	9624	0.52%	23	418.43	LIVEPERSON LivePerson, Inc
22	9583	9496	0.52%	1339	7.09	SIFY-AS-IN Sify Limited
23	24560	9023	0.49%	1098	8.22	AIRTELBROADBAND-AS-AP Bharti Airtel Ltd., Telemedia Services
24	5668	8960	0.48%	150	59.73	AS 5668 - CenturyTel Internet Holdings, Inc

bgpupdates.potaroo.net/instability/bgpupd.html

Apple Smart Bookmarks Popular Philip TinyURL! Networking Miscellaneous Most Visited APNIC Radio Most Visited

The BGP Instability Report

50 Most active Prefixes for the past 7 days

RANK	PREFIX	UPDs	%	Origin AS -- AS NAME
1	109.161.64.0/20	20959	1.05%	13118 -- ASN-YARTELECOM OJSC Rostelecom
2	103.243.164.0/22	13537	0.68%	59217 -- AZONNELIMITED-AS-AP Azonne Limited
3	89.221.206.0/24	10295	0.52%	41691 -- SUMTEL-AS-RIPE Summa Telecom LLC
4	192.58.232.0/24	10163	0.51%	6629 -- NOAA-AS - NOAA
5	120.28.62.0/24	9338	0.47%	4775 -- GLOBE-TELECOM-AS Globe Telecoms
6	222.127.0.0/24	9085	0.46%	4775 -- GLOBE-TELECOM-AS Globe Telecoms
7	208.70.20.0/22	7061	0.35%	14287 -- TRIAD-TELECOM - Triad Telecom, Inc.
8	208.73.244.0/22	7049	0.35%	14287 -- TRIAD-TELECOM - Triad Telecom, Inc.
9	208.88.232.0/22	7043	0.35%	14287 -- TRIAD-TELECOM - Triad Telecom, Inc.
10	208.78.116.0/22	7041	0.35%	14287 -- TRIAD-TELECOM - Triad Telecom, Inc.
11	216.162.0.0/20	7035	0.35%	14287 -- TRIAD-TELECOM - Triad Telecom, Inc.
12	206.152.15.0/24	6971	0.35%	54465 -- QPM-AS-1 - QuickPlay Media Inc.
13	148.218.0.0/16	6823	0.34%	11172 -- Alestra, S. de R.L. de C.V. 28477 -- UNIVERSIDAD AUTONOMA DEL ESTADO DE MORELOS
14	85.249.160.0/20	6549	0.33%	41691 -- SUMTEL-AS-RIPE Summa Telecom LLC
15	67.210.190.0/23	6226	0.31%	11976 -- FIDN - Fidelity Communication International Inc.
16	194.105.61.0/24	5827	0.29%	12922 -- MULTITRADE-AS Bank Outsourcer
17	199.187.118.0/24	4838	0.24%	11054 -- LIVEPERSON LivePerson, Inc
18	67.210.188.0/23	4765	0.24%	11976 -- FIDN - Fidelity Communication International Inc.
19	103.2.238.0/24	4584	0.23%	45194 -- SIPL-AS Syscon Infoway Pvt. Ltd., Internet Service Provider, India. 56097 -- JOISTER-AS Joister Group of Companies.
20	183.87.110.0/24	4584	0.23%	45194 -- SIPL-AS Syscon Infoway Pvt. Ltd., Internet Service Provider, India. 56097 -- JOISTER-AS Joister Group of Companies.
21	165.156.25.0/24	4501	0.23%	30437 -- GE-MS003 - General Electric Company
22	168.223.206.0/23	4213	0.21%	7202 -- FAMU - Florida A & M University
23	168.223.200.0/22	4185	0.21%	7202 -- FAMU - Florida A & M University
24	69.38.178.0/24	3923	0.20%	19406 -- TWRS-MA - Towerstream I, Inc.
26	170.128.223.0/24	3674	0.18%	11685 -- HNBCOL-AS - Huntington National Bank
27	205.166.53.0/24	3038	0.15%	22747 -- TCIS - TulsaConnect, LLC



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?