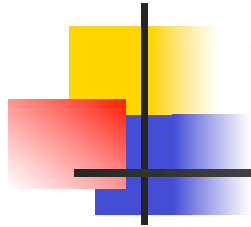


# Internet Routing Table Analysis Update



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Philip Smith  
SANOG 22  
6 August 2013  
Mumbai



# 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      6 August 2013

|   |            |
|---|------------|
| BGP routing table entries examined:                           | 462710     |
| Prefixes after maximum aggregation:                           | 187040     |
| Deaggregation factor:   | 2.47       |
| Unique aggregates announced to Internet:                      | 228636     |
| Total ASes present in the Internet Routing Table:             | 44616      |
| Prefixes per ASN:   | 10.37      |
| Origin-only ASes present in the Internet Routing Table:       | 34922      |
| Origin ASes announcing only one prefix:                       | 16180      |
| Transit ASes present in the Internet Routing Table:           | 5875       |
| Transit-only ASes present in the Internet Routing Table:      | 161        |
| Average AS path length visible in the Internet Routing Table: | 4.6        |
| Max AS path length visible:                                   | 29         |
| Max AS path prepend of ASN ( 36992)                           | 22         |
| Prefixes from unregistered ASNs in the Routing Table:         | 4415       |
| Unregistered ASNs in the Routing Table:                       | 1475       |
| Number of 32-bit ASNs allocated by the RIRs:                  | 4926       |
| Number of 32-bit ASNs visible in the Routing Table:           | 3819       |
| Prefixes from 32-bit ASNs in the Routing Table:               | 11494      |
| Special use prefixes present in the Routing Table:            | 29         |
| Prefixes being announced from unallocated address space:      | 276        |
| Number of addresses announced to Internet:                    | 2631682796 |
| Equivalent to 156 /8s, 220 /16s and 74 /24s                   |            |
| Percentage of available address space announced:              | 71.1       |
| Percentage of allocated address space announced:              | 71.1       |
| Percentage of available address space allocated:              | 100.0      |
| Percentage of address space in use by end-sites:              | 94.8       |
| Total number of prefixes smaller than registry allocations:   | 162457     |

## APNIC Region

|  |           |
|--|-----------|
| Prefixes being announced by APNIC Region ASes:                   | 111318    |
| Total APNIC prefixes after maximum aggregation:                  | 33953     |
| APNIC Deaggregation factor:                                      | 3.28      |
| Prefixes being announced from the APNIC address blocks:          | 113078    |
| Unique aggregates announced from the APNIC address blocks:       | 46182     |
| APNIC Region origin ASes present in the Internet Routing Table:  | 4862      |
| APNIC Prefixes per ASN:  | 23.26     |
| APNIC Region origin ASes announcing only one prefix:             | 1220      |
| APNIC Region transit ASes present in the Internet Routing Table: | 823       |
| Average APNIC Region AS path length visible:                     | 4.7       |
| Max APNIC Region AS path length visible:                         | 28        |
| Number of APNIC region 32-bit ASNs visible in the Routing Table: | 624       |
| Number of APNIC addresses announced to Internet:                 | 725715680 |
| Equivalent to 43 /8s, 65 /16s and 138 /24s                       |           |
| Percentage of available APNIC address space announced:           | 84.8      |

|                       |  |
|-----------------------|--|
| APNIC AS Blocks       | 4608-4864, 7467-7722, 9216-10239, 17408-18431  |
| (pre-ERX allocations) | 23552-24575, 37888-38911, 45056-46079, 55296-56319,<br>58368-59391, 131072-133119  |
| APNIC Address Blocks  | 1/8, 14/8, 27/8, 36/8, 39/8, 42/8, 43/8,<br>49/8, 58/8 to 61/8, 101/8, 103/8, 106/8,<br>110/8 to 126/8, 133/8, 175/8, 180/8, 182/8, 183/8,<br>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 | 2986       | 1591      | 110     | NET Servicos de Comunicacao S.A |
| 6389  | 2981       | 3689      | 63      | bellsouth.net, inc.             |
| 4766  | 2920       | 11561     | 917     | Korea Telecom (KIX)             |
| 10620 | 2652       | 421       | 228     | TVCABLE BOGOTA                  |
| 17974 | 2650       | 871       | 92      | PT TELEKOMUNIKASI INDONESIA     |
| 18566 | 2065       | 382       | 184     | Covad Communications            |
| 7545  | 2036       | 320       | 110     | TPG Internet Pty Ltd            |
| 1785  | 2005       | 679       | 125     | PaeTec Communications, Inc.     |
| 22773 | 2002       | 2927      | 123     | Cox Communications, Inc.        |
| 36998 | 1861       | 112       | 5       | MOBITEL                         |
| 4755  | 1779       | 393       | 197     | TATA Communications formerly    |
| 7303  | 1729       | 1156      | 221     | Telecom Argentina Stet-France   |
| 8402  | 1697       | 544       | 16      | Corbina telecom                 |
| 20115 | 1672       | 1624      | 623     | Charter Communications          |
| 4323  | 1621       | 1106      | 408     | Time Warner Telecom             |
| 9829  | 1536       | 1221      | 45      | BSNL National Internet Backbo   |
| 701   | 1523       | 11104     | 800     | UUNET Technologies, Inc.        |
| 30036 | 1357       | 307       | 651     | Mediacom Communications Corp    |
| 7018  | 1317       | 11037     | 830     | AT&T WorldNet Services          |
| 34984 | 1299       | 244       | 221     | BILISIM TELEKOM                 |

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    | /12:249    |
| /13:480   | /14:905   | /15:1602  | /16:12736 | /17:6650  | /18:11095  |
| /19:22564 | /20:32224 | /21:34705 | /22:48723 | /23:42680 | /24:244036 |
| /25:1279  | /26:1640  | /27:840   | /28:44    | /29:73    | /30:18     |
| /31:0     | /32:18    |           |           |           |            |

August 2013 ↑

August 2012 ↓

## Number of prefixes announced by prefix length

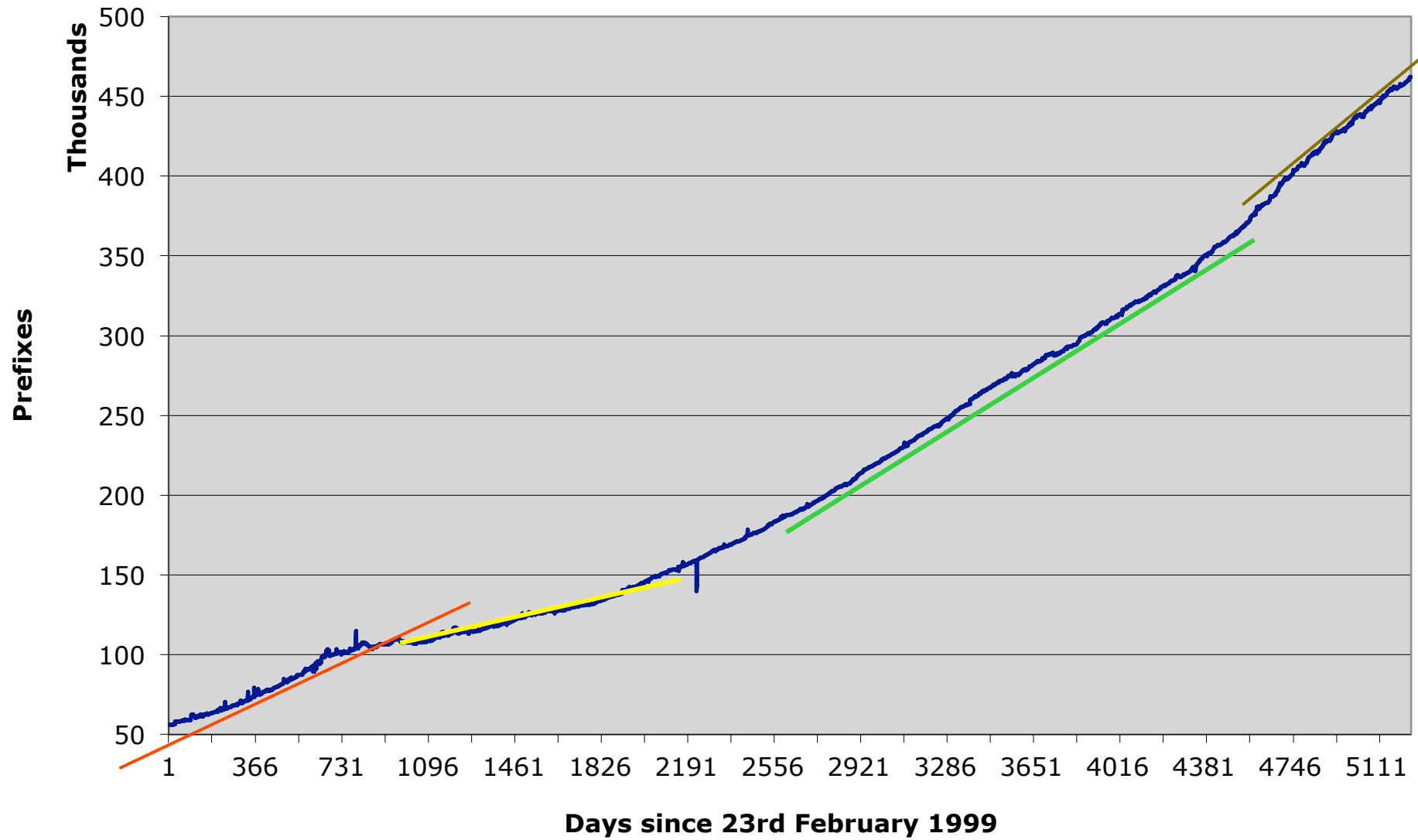
|           |           |           |           |           |            |
|-----------|-----------|-----------|-----------|-----------|------------|
| /1:0      | /2:0      | /3:0      | /4:0      | /5:0      | /6:0       |
| /7:0      | /8:19     | /9:12     | /10:28    | /11:82    | /12:236    |
| /13:474   | /14:849   | /15:1529  | /16:12336 | /17:6370  | /18:10753  |
| /19:20961 | /20:29914 | /21:31864 | /22:41583 | /23:39657 | /24:220449 |
| /25:1275  | /26:1507  | /27:853   | /28:163   | /29:62    | /30:18     |
| /31:0     | /32:24    |           |           |           |            |

## Prefixes Smaller than Registry Allocations

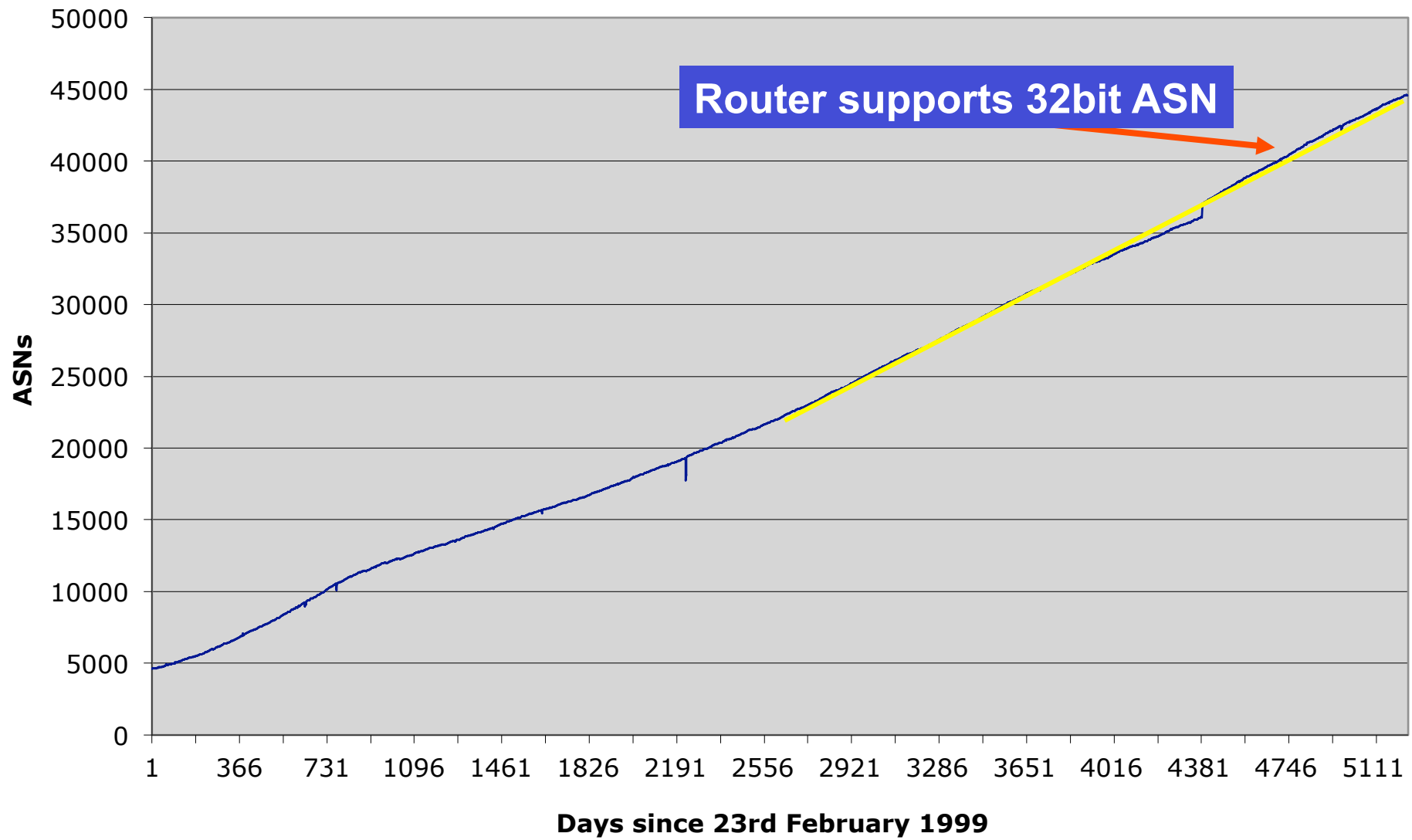
| ASN   | No of nets | Total ann. | Description                     |
|-------|------------|------------|---------------------------------|
| 18566 | 2016       | 2065       | Covad Communications            |
| 36998 | 1826       | 1861       | MOBITEL                         |
| 6389  | 1715       | 2981       | bellsouth.net, inc.             |
| 8402  | 1397       | 1697       | Corbina telecom                 |
| 22773 | 1303       | 2002       | Cox Communications, Inc.        |
| 30036 | 1218       | 1357       | Mediacom Communications Corp    |
| 11492 | 1182       | 1221       | Cable One                       |
| 1785  | 1078       | 2005       | PaeTec Communications, Inc.     |
| 6983  | 1020       | 1148       | ITC^Deltacom                    |
| 10620 | 987        | 2652       | TVCABLE BOGOTA                  |
| 22561 | 942        | 1208       | Digital Teleport, Inc           |
| 7011  | 926        | 1170       | Citizens Utilities              |
| 31148 | 921        | 977        | FreeNet ISP                     |
| 34984 | 860        | 1299       | BILISIM TELEKOM                 |
| 13977 | 832        | 846        | FAIRPOINT COMMUNICATIONS, INC   |
| 4766  | 802        | 2920       | Korea Telecom (KIX)             |
| 13188 | 685        | 839        | Educational Network             |
| 28573 | 668        | 2986       | NET Servicos de Comunicacao S.A |
| 27947 | 667        | 836        | Telconet S.A                    |
| 3356  | 636        | 1093       | Level 3 Communications, LLC     |

AfriNIC APNIC ARIN LACNIC RIPE NCC

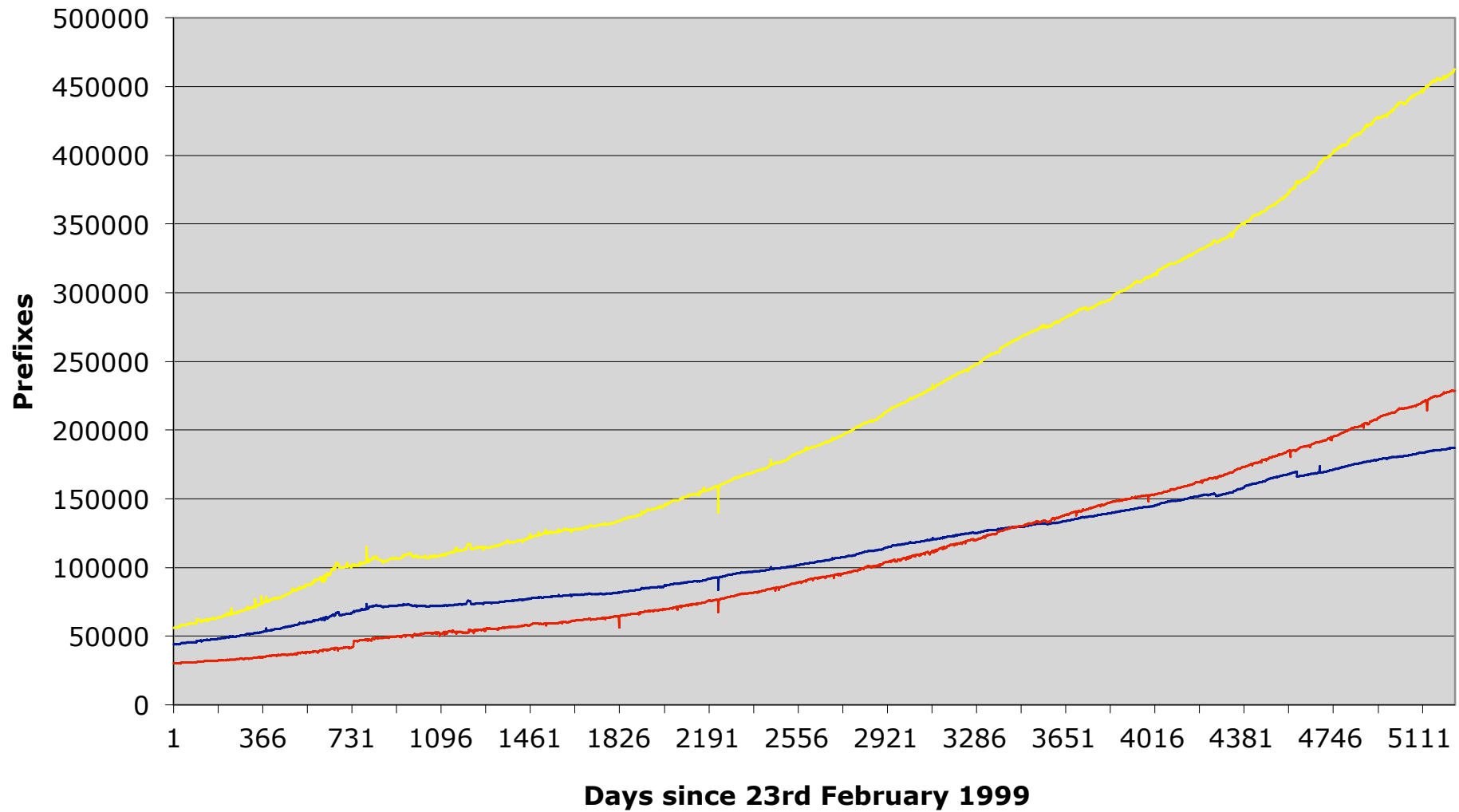
## BGP Routing Table



## AS Growth



## Max Aggregation vs Unique Prefixes

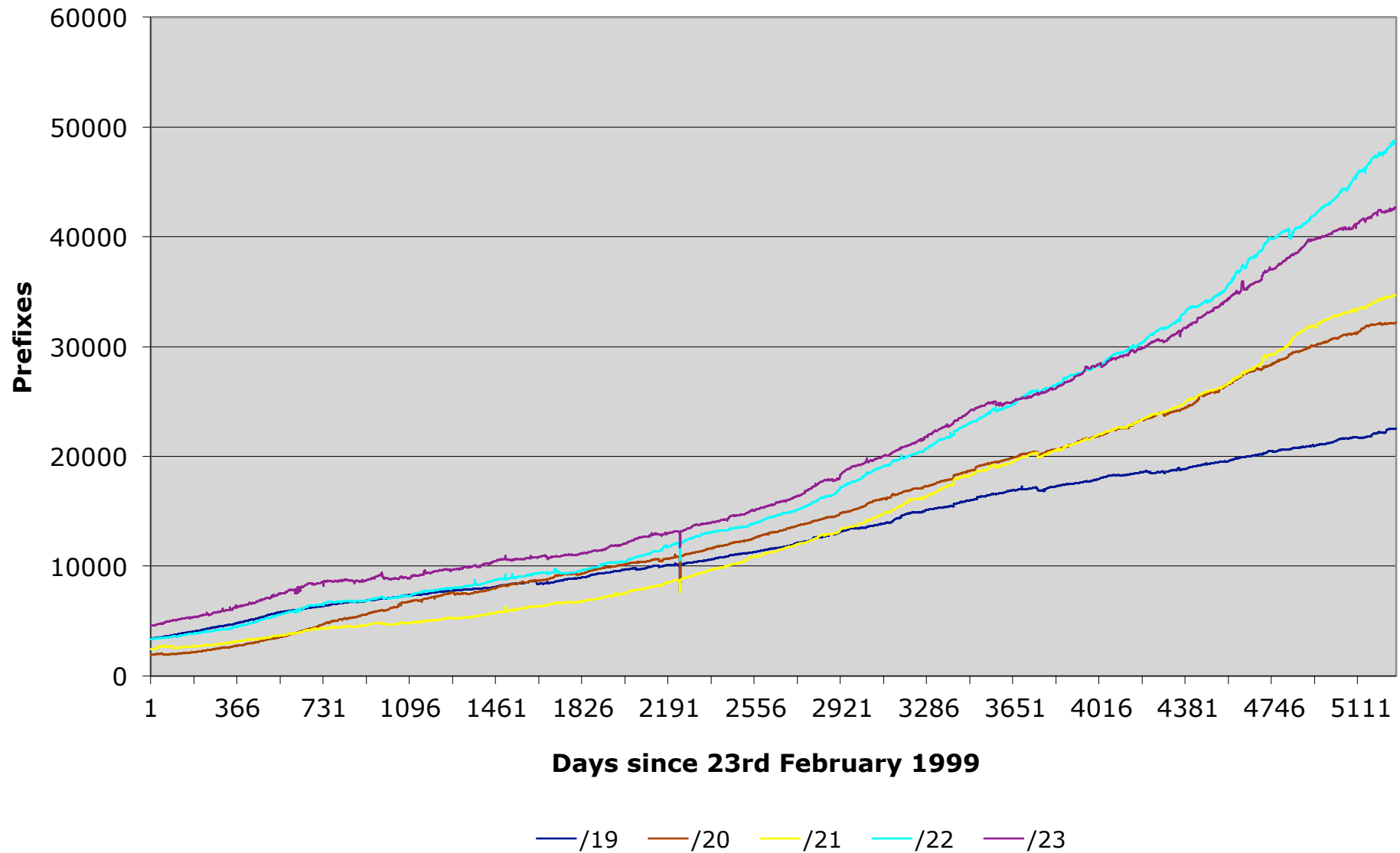


— Max Aggregation

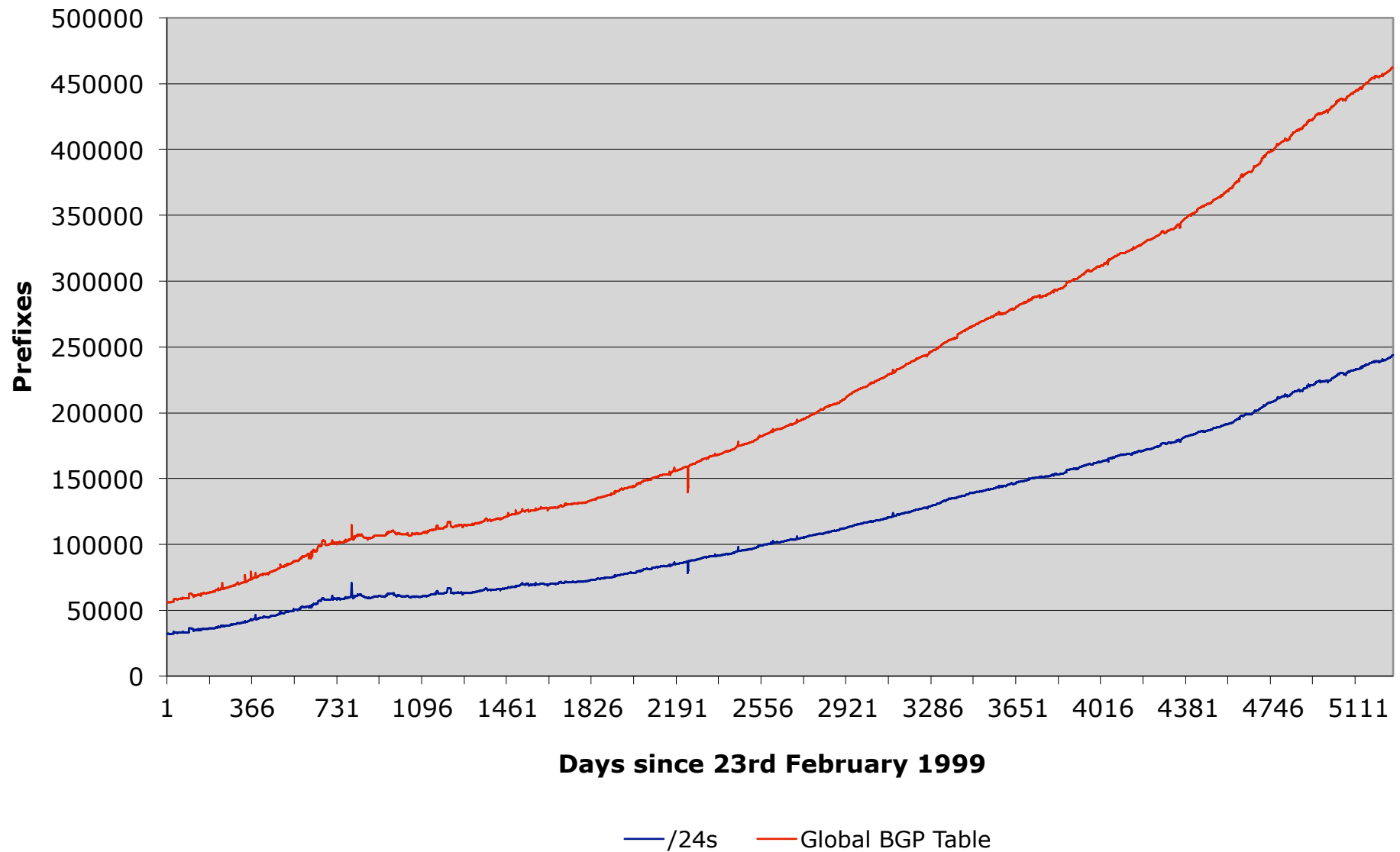
— Unique Prefixes

— Global BGP Table

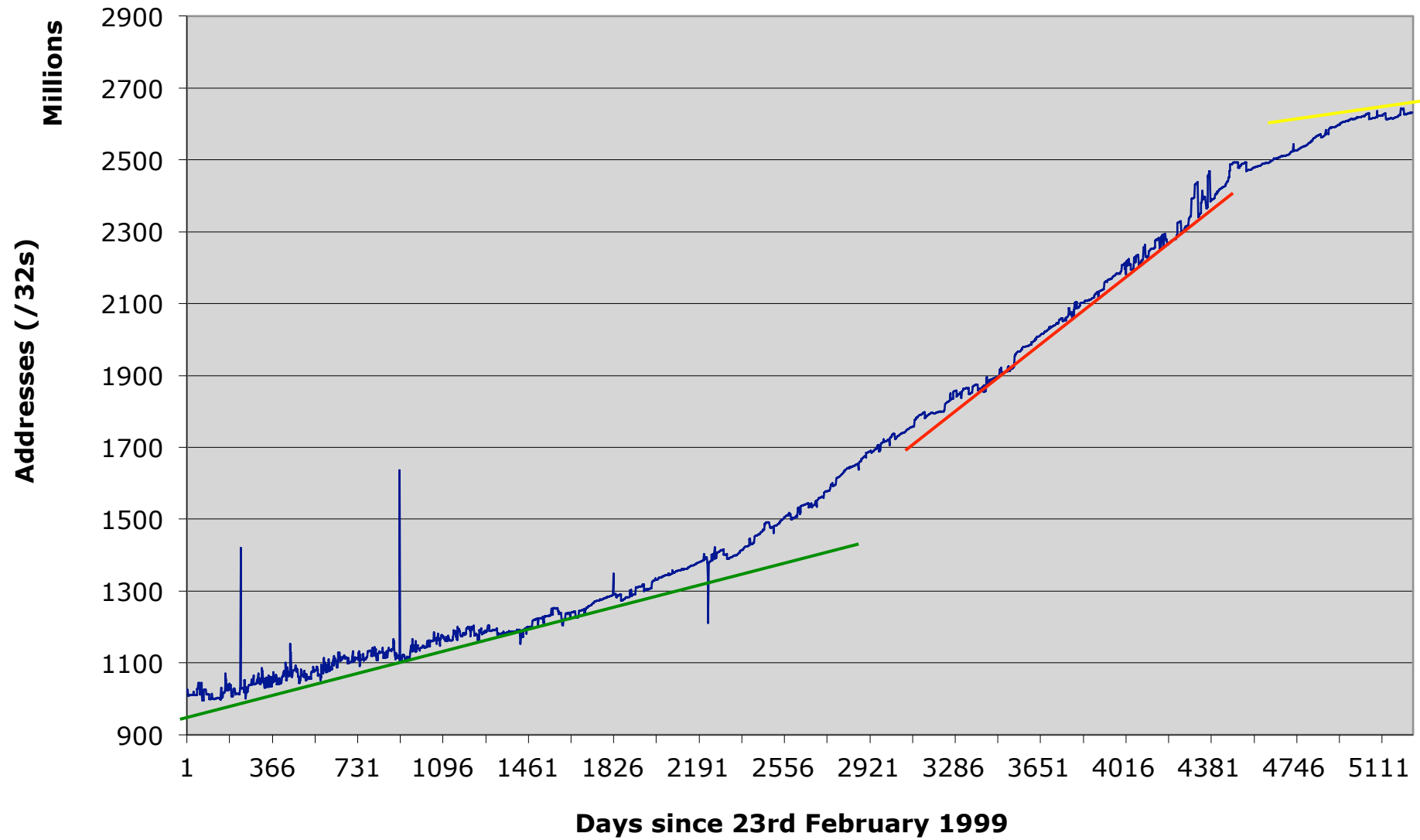
## Prefix sizes announced



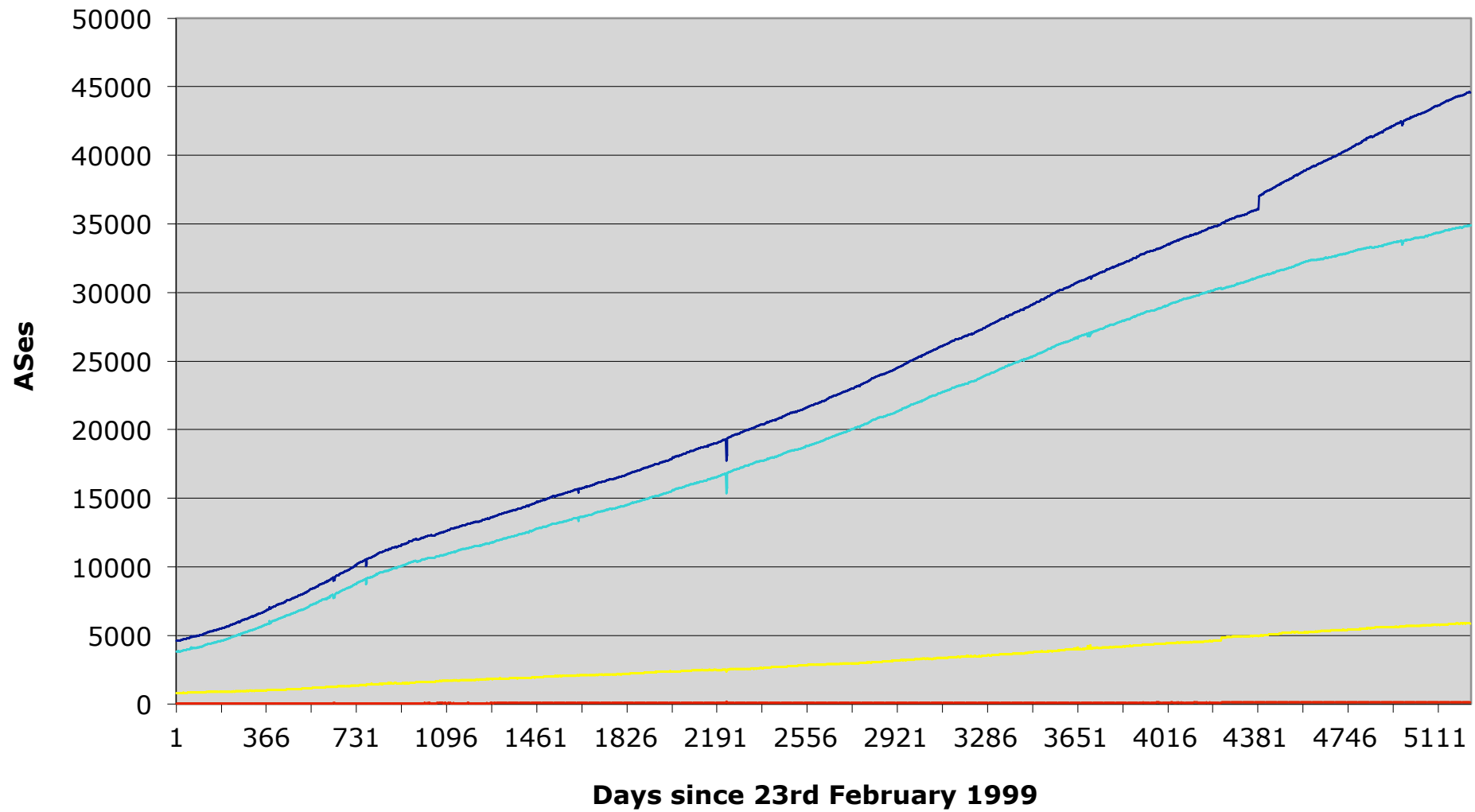
## /24s announced



## Address Space announced



## AS Announcements



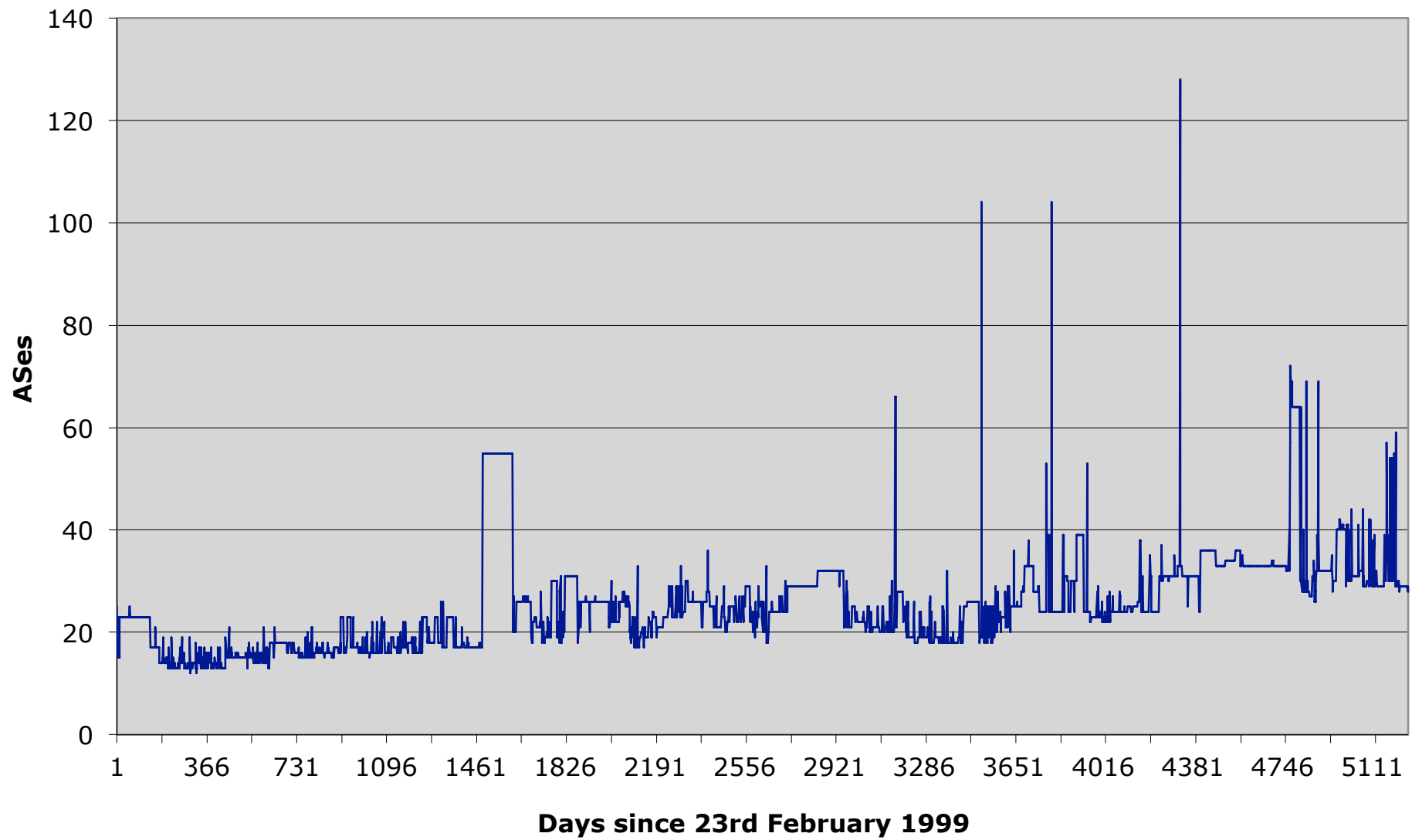
— Total ASNs

— Origin-only ASNs

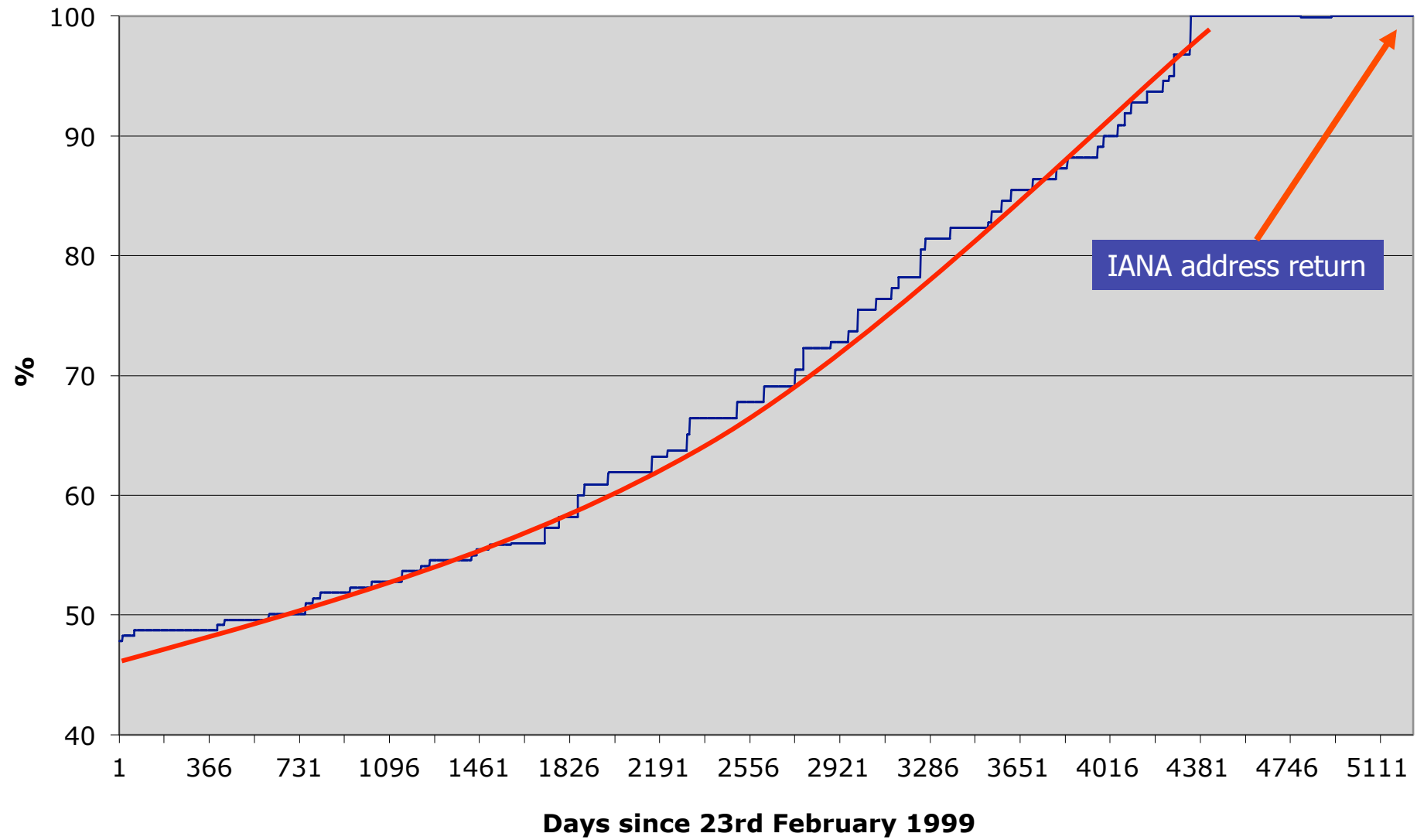
— ASN providing Transit & Origin

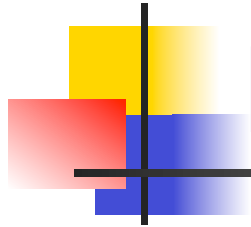
— Transit-only ASNs

## Maximum AS Path Length



## Growth in IPv4 Address Space Allocations

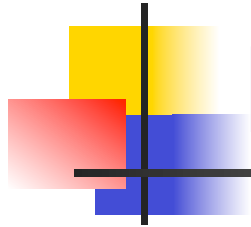




# Looking at Deaggregation

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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”



# August 2013

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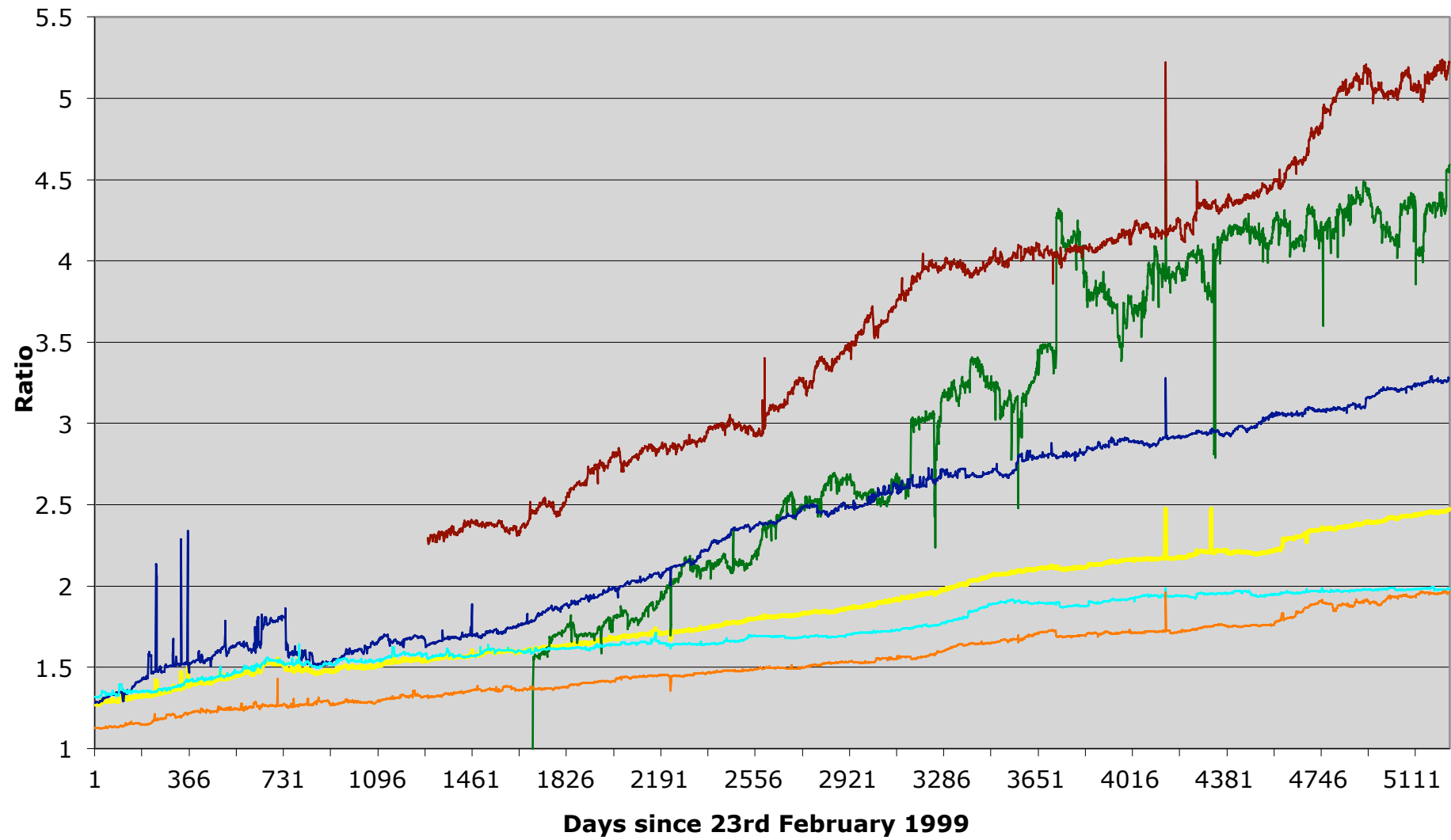
## Total Prefixes

- Global BGP Table
  - 463k prefixes
- Europe & Middle East
  - 118k prefixes
- North America
  - 160k prefixes
- Asia & Pacific
  - 111k prefixes
- Africa
  - 12k prefixes
- Latin America & Caribbean
  - 50k prefixes

## Deaggregation Factor

- Global Average
  - 2.47
- Europe & Middle East
  - 1.96
- North America
  - 1.98
- Asia & Pacific
  - 3.28
- Africa
  - 4.59
- Latin America & Caribbean
  - 5.22

## Deaggregation: RIR Regions vs Global



Global AfriNIC APNIC ARIN LACNIC RIPE

## Asia Pacific Aggregation Savings Summary

| ASN   | No of Nets | Savings | Description                   |
|-------|------------|---------|-------------------------------|
| 17974 | 2650       | 2558    | PT TELEKOMUNIKASI INDONESIA   |
| 4766  | 2920       | 2003    | Korea Telecom (KIX)           |
| 7545  | 2036       | 1926    | TPG Internet Pty Ltd          |
| 4755  | 1779       | 1582    | TATA Communications formerly  |
| 9829  | 1536       | 1491    | BSNL National Internet Backbo |
| 7552  | 1131       | 1118    | Vietel Corporation            |
| 9498  | 1175       | 1105    | BHARTI Airtel Ltd.            |
| 24560 | 1087       | 923     | Bharti Airtel Ltd., Telemedia |
| 4808  | 1159       | 823     | CNCGROUP IP network: China169 |
| 18101 | 982        | 810     | Reliance Infocom Ltd Internet |
| 4780  | 873        | 805     | Digital United Inc.           |
| 9808  | 774        | 761     | Guangdong Mobile Communicatio |
| 17908 | 803        | 747     | Tata Communications           |
| 9583  | 1224       | 720     | Sify Limited                  |
| 4788  | 765        | 716     | Telekom Malaysia              |
| 45528 | 708        | 657     | Tikona Digital Networks,      |
| 18403 | 644        | 632     | The Corporation for Financing |
| 17676 | 752        | 626     | Softbank BB Corp.             |
| 18207 | 554        | 526     | IQARA BROADBAND               |
| 17623 | 552        | 499     | China Netcom Corp.            |

<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

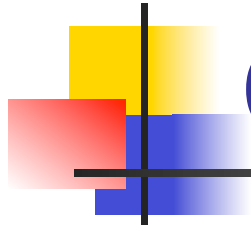
The BGP Instability Report is updated daily. This report was generated on 05 August 2013 06:18 (UTC+1000)

## 50 Most active ASes for the past 7 days

| RANK | ASN                   | UPDs  | %     | Prefixes | UPDs/Prefix | AS NAME  |
|------|-----------------------|-------|-------|----------|-------------|--|
| 1    | <a href="#">50710</a> | 39903 | 2.15% | 239      | 166.96      | EARTHLINK-AS EarthLink Ltd. Communications&Internet Services   |
| 2    | <a href="#">9829</a>  | 35585 | 1.91% | 1538     | 23.14       | BSNL-NIB National Internet Backbone                            |
| 3    | <a href="#">35819</a> | 33148 | 1.78% | 480      | 69.06       | MOBILY-AS Etihad Etisalat Company (Mobily)                     |
| 4    | <a href="#">8402</a>  | 32704 | 1.76% | 1973     | 16.58       | CORBINA-AS OJSC "Vimpelcom"                                    |
| 5    | <a href="#">7552</a>  | 29974 | 1.61% | 1172     | 25.58       | VIETEL-AS-AP Vietel Corporation                                |
| 6    | <a href="#">27738</a> | 25176 | 1.35% | 576      | 43.71       | Ecuadortelecom S.A.  |
| 7    | <a href="#">36998</a> | 20171 | 1.08% | 1861     | 10.84       | SDN-MOBITEL  |
| 8    | <a href="#">17974</a> | 18427 | 0.99% | 2654     | 6.94        | TELKOMNET-AS2-AP PT Telekomunikasi Indonesia                   |
| 9    | <a href="#">9416</a>  | 18046 | 0.97% | 67       | 269.34      | MULTIMEDIA-AS-AP Hoshin Multimedia Center Inc.                 |
| 10   | <a href="#">18403</a> | 17548 | 0.94% | 719      | 24.41       | FPT-AS-AP The Corporation for Financing & Promoting Technology |
| 11   | <a href="#">4775</a>  | 16348 | 0.88% | 129      | 126.73      | GLOBE-TELECOM-AS Globe Telecoms                                |
| 12   | <a href="#">10428</a> | 14802 | 0.80% | 7        | 2114.57     | CWV-NETWORKS - The College of West Virginia                    |
| 13   | <a href="#">18025</a> | 12563 | 0.68% | 55       | 228.42      | ACE-1-WIFI-AS-AP Ace-1 Wifi Network                            |
| 14   | <a href="#">34969</a> | 12544 | 0.67% | 8        | 1568.00     | PASJONET-AS Pasjo.Net Sp, z o.o.                               |
| 15   | <a href="#">28573</a> | 11686 | 0.63% | 3002     | 3.89        | NET Serviços de Comunicação S.A.                               |
| 16   | <a href="#">45400</a> | 10185 | 0.55% | 562      | 18.12       | NICNET Korea Telecom-PUBNET                                    |
| 17   | <a href="#">48612</a> | 9597  | 0.52% | 14       | 685.50      | RTC-ORENBURG-AS CJSC "Comstar-Regions"                         |
| 18   | <a href="#">6629</a>  | 9382  | 0.50% | 65       | 144.34      | NOAA-AS - NOAA   |
| 19   | <a href="#">17841</a> | 9327  | 0.50% | 591      | 15.78       | NCIA-AS-KR MIC E-GOVERNMENT                                    |
| 20   | <a href="#">2118</a>  | 9234  | 0.50% | 1235     | 7.48        | RELCOM-AS OOO "NPO Relcom"                                     |
| 21   | <a href="#">14287</a> | 9164  | 0.49% | 63       | 145.46      | TRIAD-TELECOM - Triad Telecom, Inc.                            |
| 22   | <a href="#">25620</a> | 8970  | 0.48% | 197      | 45.53       | COTAS LTDA.  |
| 23   | <a href="#">38654</a> | 8361  | 0.45% | 6        | 1393.50     | INES-NETWORK INES Corporation.                                 |
| 24   | <a href="#">24532</a> | 8121  | 0.44% | 46       | 176.54      | INET-AS-ID PT. Inet Global Indo                                |

## 50 Most active Prefixes for the past 7 days

| RANK | PREFIX                           | UPDs | %     | Origin AS -- AS NAME   |
|------|----------------------------------|------|-------|--|
| 1    | <a href="#">92.246.207.0/24</a>  | 9433 | 0.47% | <a href="#">48612 -- RTC-ORENBURG-AS CJSC "Comstar-Regions"</a>                                      |
| 2    | <a href="#">192.58.232.0/24</a>  | 9346 | 0.47% | <a href="#">6629 -- NOAA-AS - NOAA</a>   |
| 3    | <a href="#">203.118.224.0/21</a> | 9083 | 0.46% | <a href="#">9416 -- MULTIMEDIA-AS-AP Hoshin Multimedia Center Inc.</a>                               |
| 4    | <a href="#">203.118.232.0/21</a> | 8936 | 0.45% | <a href="#">9416 -- MULTIMEDIA-AS-AP Hoshin Multimedia Center Inc.</a>                               |
| 5    | <a href="#">150.39.0.0/16</a>    | 8357 | 0.42% | <a href="#">38654 -- INES-NETWORK INES Corporation.</a>  |
| 6    | <a href="#">120.28.62.0/24</a>   | 7673 | 0.39% | <a href="#">4775 -- GLOBE-TELECOM-AS Globe Telecoms</a>  |
| 7    | <a href="#">222.127.0.0/24</a>   | 7627 | 0.38% | <a href="#">4775 -- GLOBE-TELECOM-AS Globe Telecoms</a>  |
| 8    | <a href="#">65.90.49.0/24</a>    | 6515 | 0.33% | <a href="#">3356 -- LEVEL3 Level 3 Communications</a>  |
| 9    | <a href="#">112.203.192.0/19</a> | 6435 | 0.32% | <a href="#">9299 -- IPG-AS-AP Philippine Long Distance Telephone Company</a>                         |
| 10   | <a href="#">190.211.175.0/24</a> | 5853 | 0.29% | <a href="#">52280 -- INTERNEXA Chile S.A.</a>  |
| 11   | <a href="#">115.170.128.0/17</a> | 5720 | 0.29% | <a href="#">4847 -- CNIX-AP China Networks Inter-Exchange</a>  |
| 12   | <a href="#">12.43.218.0/24</a>   | 4902 | 0.25% | <a href="#">10428 -- CWV-NETWORKS - The College of West Virginia</a>                                 |
| 13   | <a href="#">199.248.240.0/24</a> | 4902 | 0.25% | <a href="#">10428 -- CWV-NETWORKS - The College of West Virginia</a>                                 |
| 14   | <a href="#">205.166.165.0/24</a> | 4902 | 0.25% | <a href="#">10428 -- CWV-NETWORKS - The College of West Virginia</a>                                 |
| 15   | <a href="#">69.38.178.0/24</a>   | 4716 | 0.24% | <a href="#">19406 -- TWRs-MA - Towerstream I, Inc.</a>   |
| 16   | <a href="#">204.29.132.0/23</a>  | 4593 | 0.23% | <a href="#">1880 -- STUPI Svensk Teleutveckling &amp; Produktinnovation, STUPI AB</a>                |
| 17   | <a href="#">207.63.128.0/18</a>  | 4314 | 0.22% | <a href="#">6325 -- ILLINOIS-CENTURY - Illinois Century Network</a>                                  |
| 18   | <a href="#">2.93.235.0/24</a>    | 4141 | 0.21% | <a href="#">8402 -- CORBINA-AS OJSC "Vimpelcom"</a>  |
| 19   | <a href="#">64.187.64.0/23</a>   | 3868 | 0.19% | <a href="#">16608 -- KENTEC - Kentec Communications, Inc.</a>  |
| 20   | <a href="#">62.84.76.0/24</a>    | 3560 | 0.18% | <a href="#">42334 -- BBP-AS Broadband Plus s.a.l.</a>  |
| 21   | <a href="#">206.105.75.0/24</a>  | 3556 | 0.18% | <a href="#">6174 -- SPRINTLINK8 - Sprint</a>   |
| 22   | <a href="#">208.16.110.0/24</a>  | 3556 | 0.18% | <a href="#">6174 -- SPRINTLINK8 - Sprint</a>   |
| 23   | <a href="#">64.187.64.0/24</a>   | 3453 | 0.17% | <a href="#">16608 -- KENTEC - Kentec Communications, Inc.</a>  |
| 24   | <a href="#">84.205.66.0/24</a>   | 2480 | 0.12% | <a href="#">12654 -- RIPE-NCC-RIS-AS Reseaux IP Europeens Network Coordination Centre (RIPE NCC)</a> |
| 25   | <a href="#">63.116.19.0/24</a>   | 2194 | 0.11% | <a href="#">19111 -- NATURES-BOUN - NBTY, Inc.</a>   |
| 26   | <a href="#">188.123.160.0/19</a> | 1995 | 0.10% | <a href="#">47887 -- NEU-AS NEU Telecom &amp; Technologies</a>                                       |
| 27   | <a href="#">178.61.252.0/23</a>  | 1895 | 0.10% | <a href="#">21050 -- FAST-TELCO Fast Telecommunications Company W.L.L.</a>                           |
| 28   | <a href="#">208.88.232.0/21</a>  | 1834 | 0.09% | <a href="#">14287 -- TRIAD-TELECOM - Triad Telecom, Inc.</a>   |
| 29   | <a href="#">208.78.116.0/22</a>  | 1834 | 0.09% | <a href="#">14287 -- TRIAD-TELECOM - Triad Telecom, Inc.</a>   |



# 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?