



Measuring the Global Routing Table

by

Alexander Afanasyev, Brent Longstaff, Neil Tilley

June 2, 2009

Outline

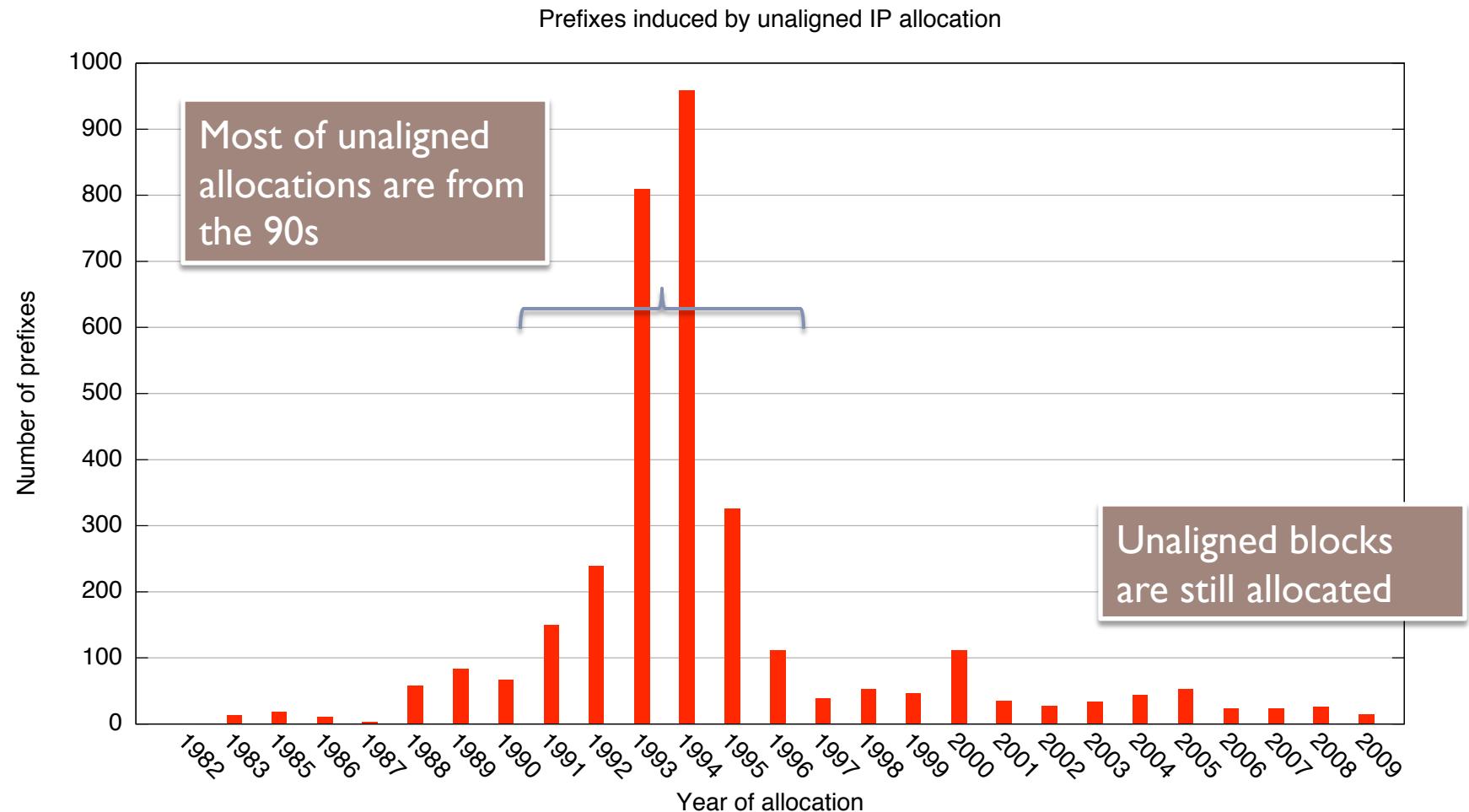
- ▶ Data sources
- ▶ Announcements, allocations, IP space usage
- ▶ Routing table growth factors
 - ▶ Prefix length
 - ▶ Longevity of announcements
 - ▶ Fragmentation
- ▶ Routing table stability
- ▶ Conclusion

Source for IP allocation history

Regional Internet Registries (RIRs)



Unaligned IP allocations



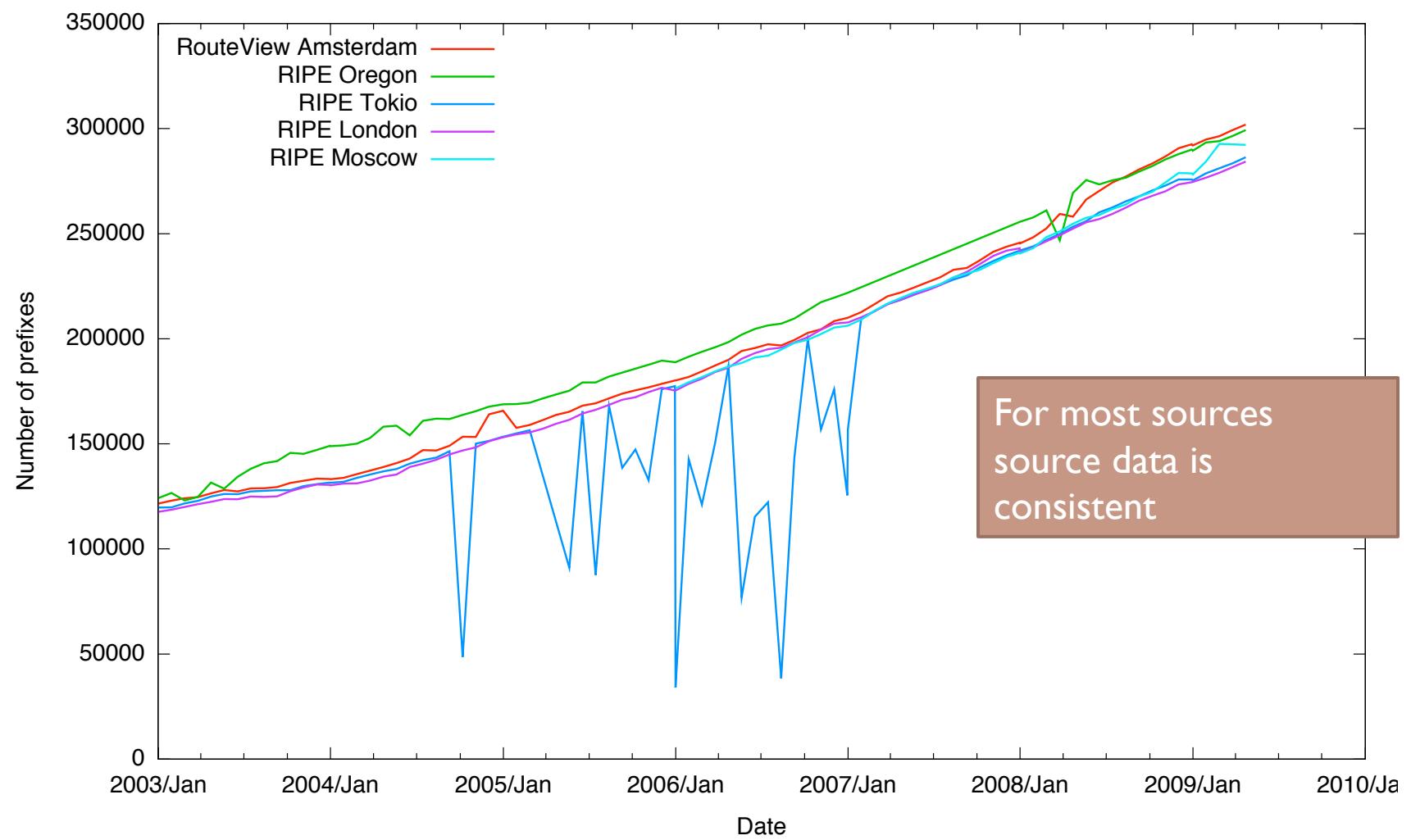
Source for BGP announcement history

BGP monitors

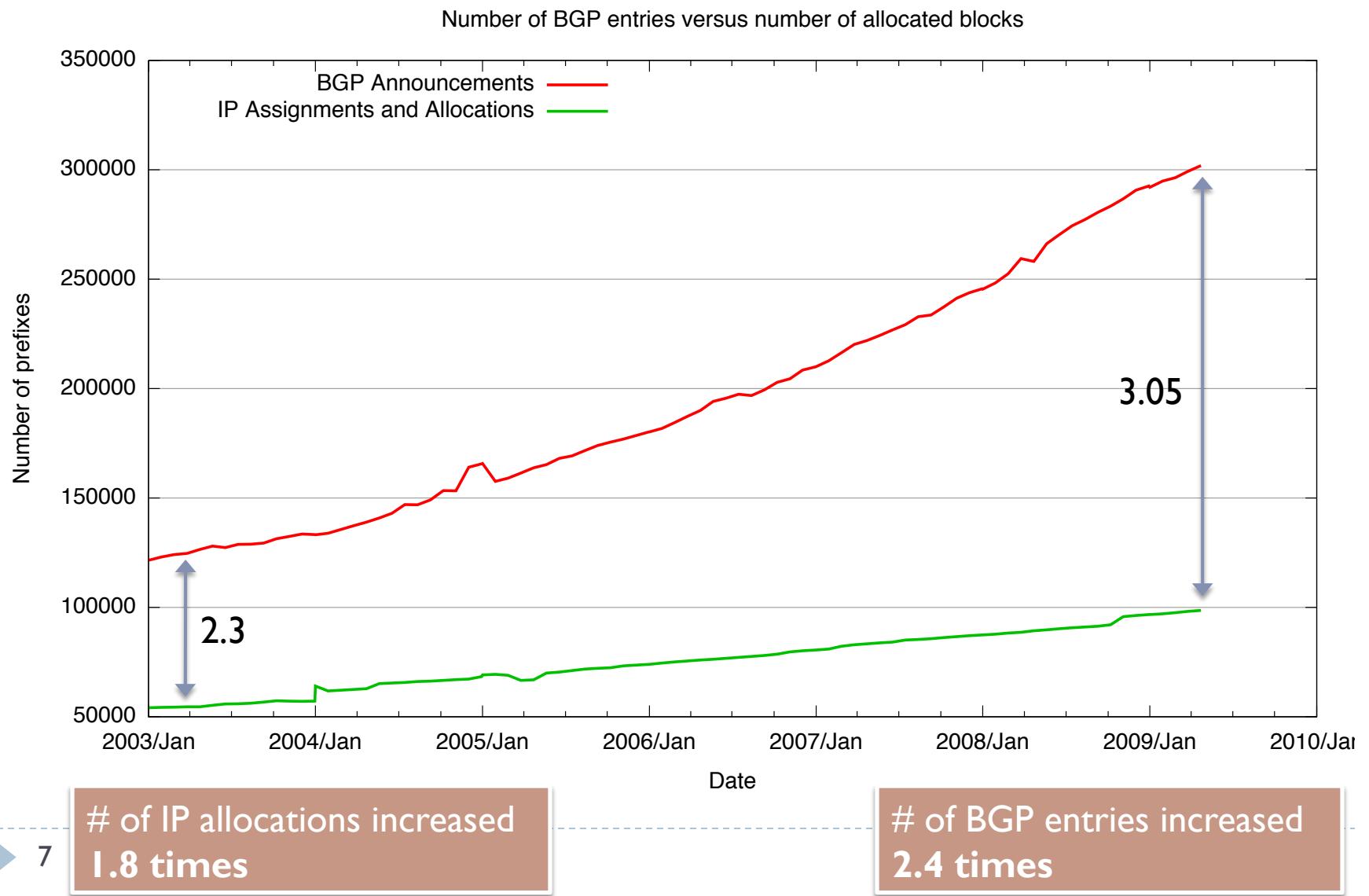
- ▶ Two BGP monitor projects
 - ▶ Route Views of U Oregon
 - ▶ Routing Information Service (RIS) of RIPE NCC
- ▶ BGP data collected throughout the world
 - ▶ Currently 24 collecting points
 - ▶ Monitors in US, Europe, Japan, Russia, and Brazil

BGP source data

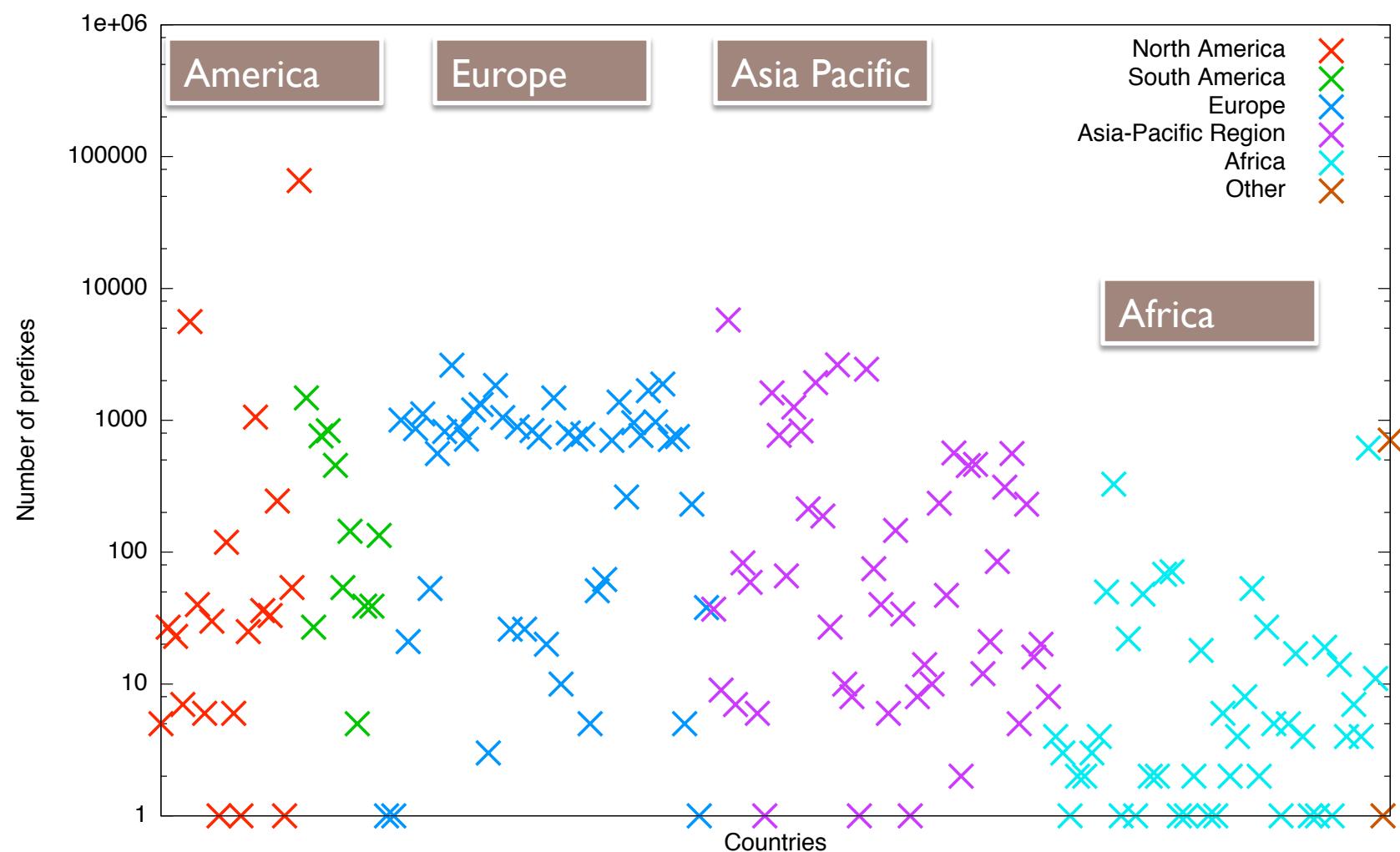
Various BGP monitors



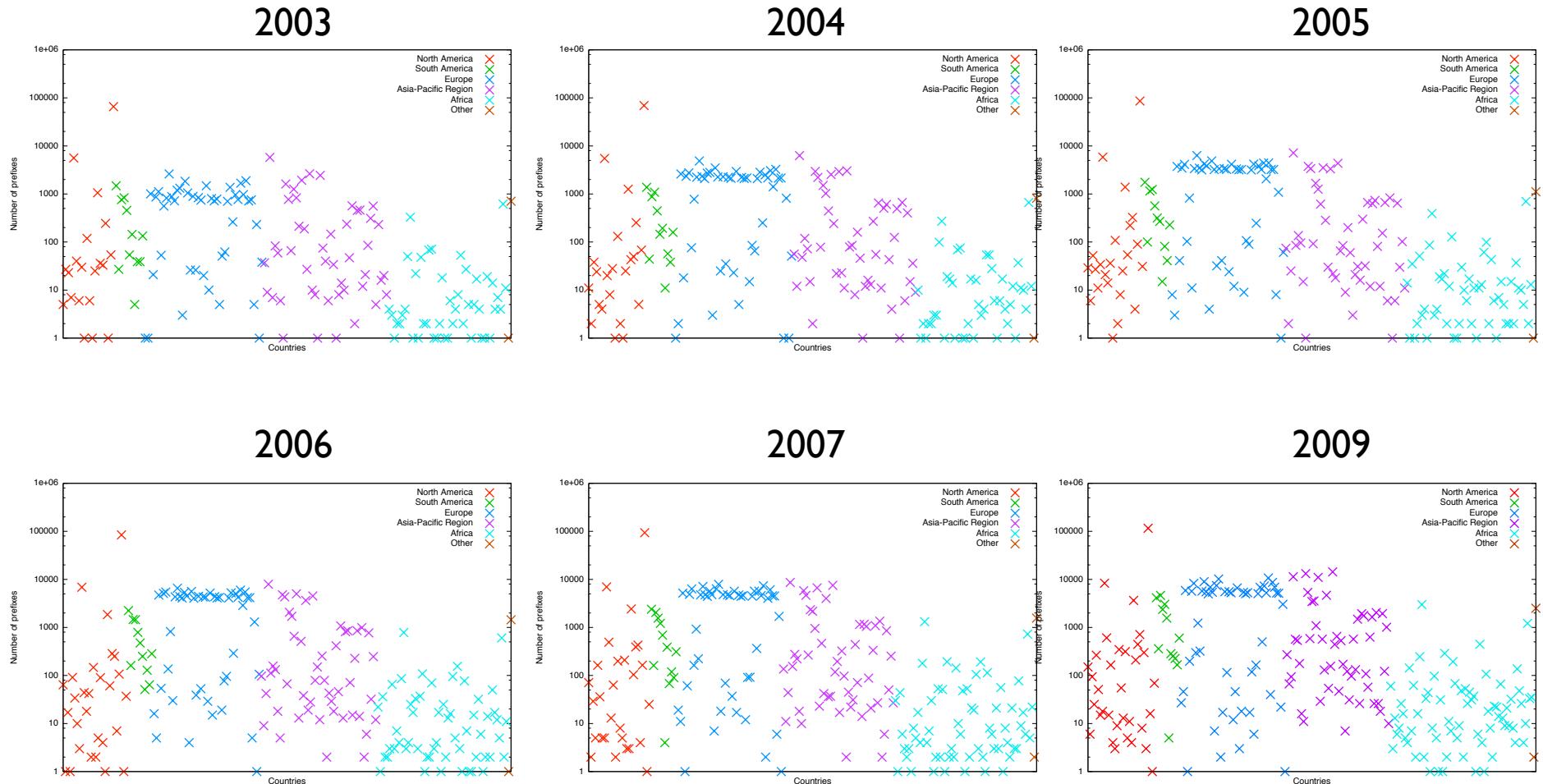
BGP announced prefixes versus IP allocated prefixes (BGP vs RIRs)



Distribution of BGP announced prefixes in 2003



Distribution of BGP announced prefixes

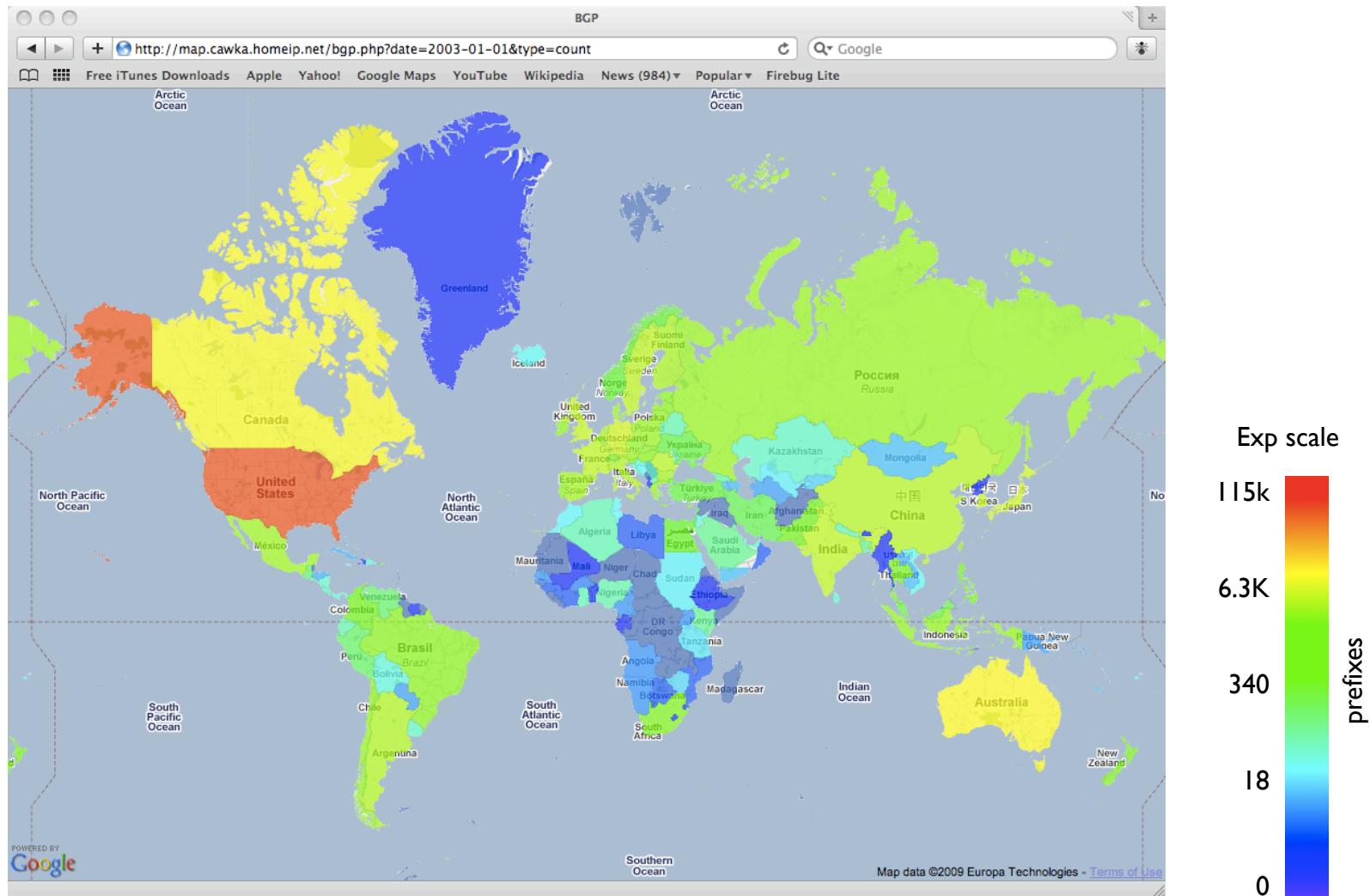


► 9

General trend - substantial growth of # announced prefixes globally

Distribution of BGP announced prefixes **2003**

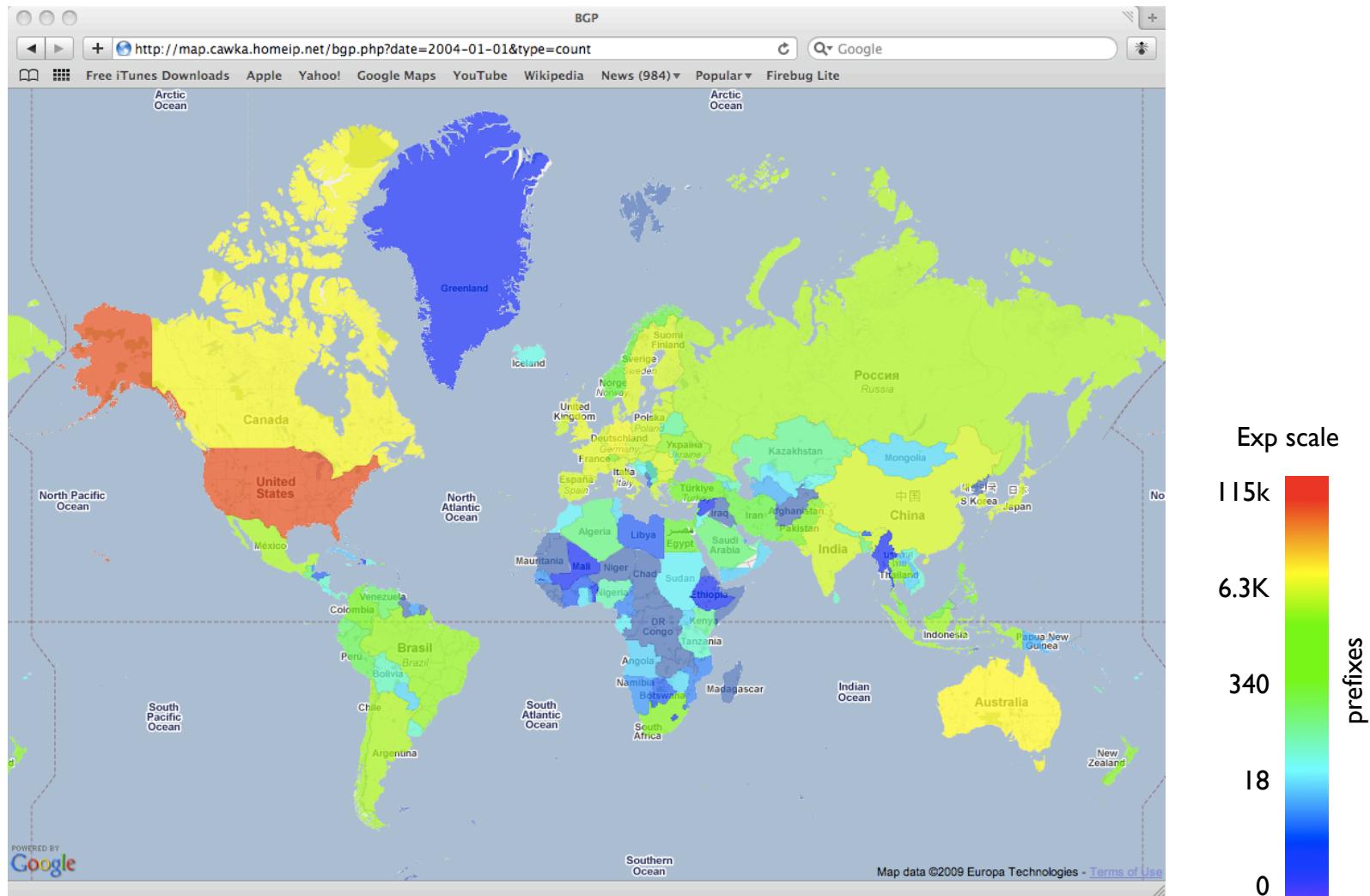
[1 / 8]



Distribution of BGP announced prefixes

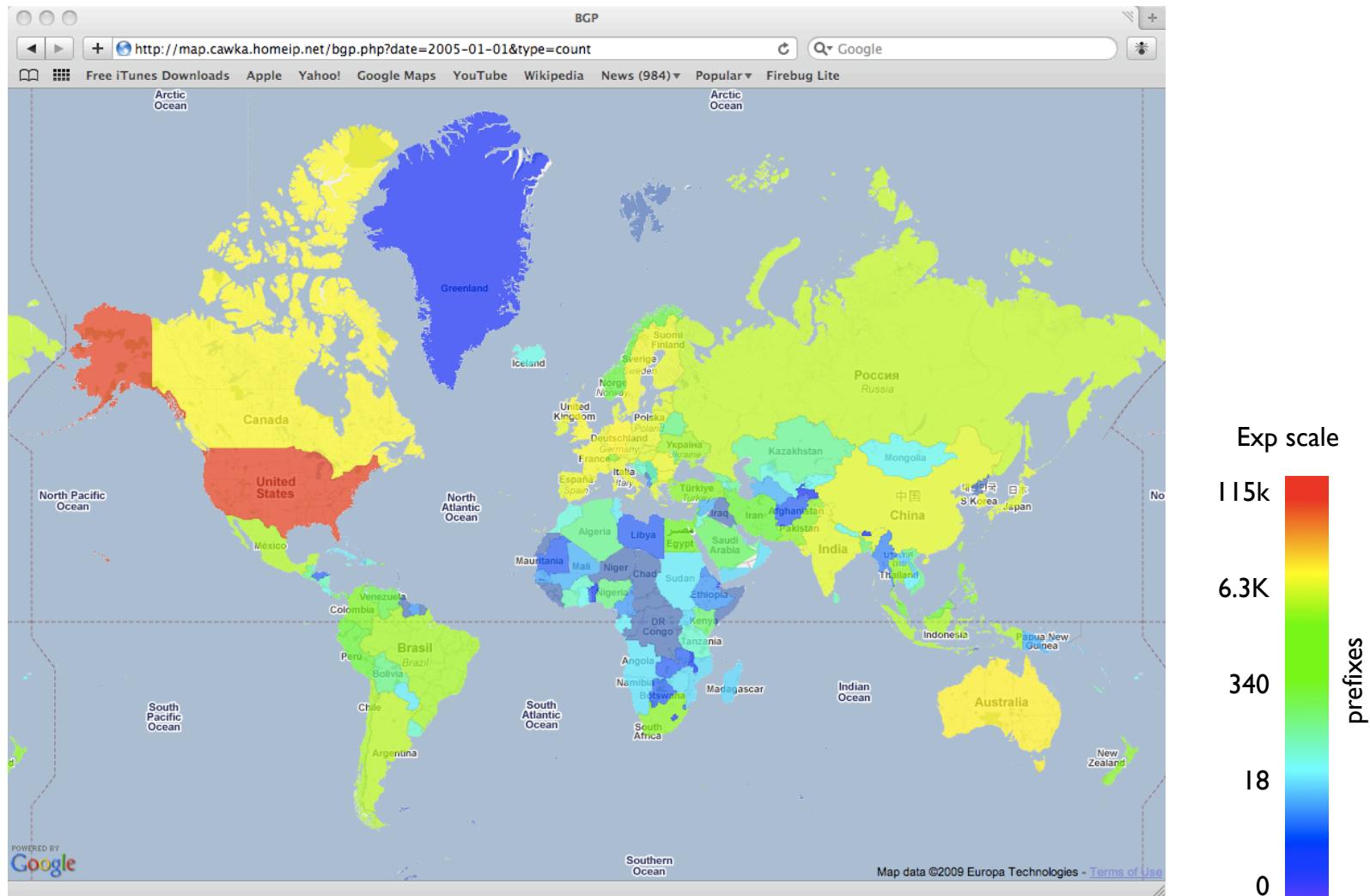
2004 [2/8]

[2/8]



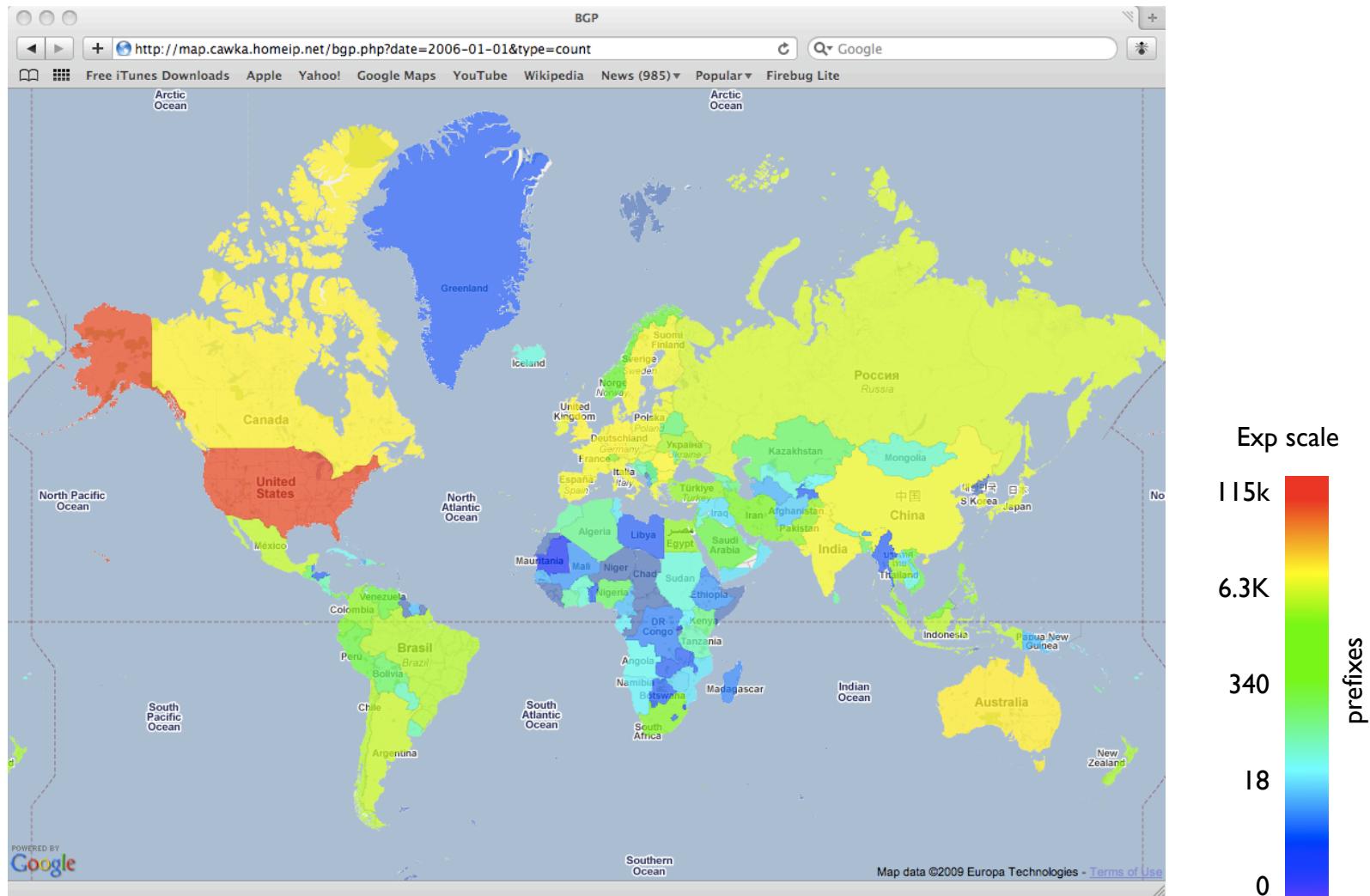
Distribution of BGP announced prefixes **2005**

[3/8]



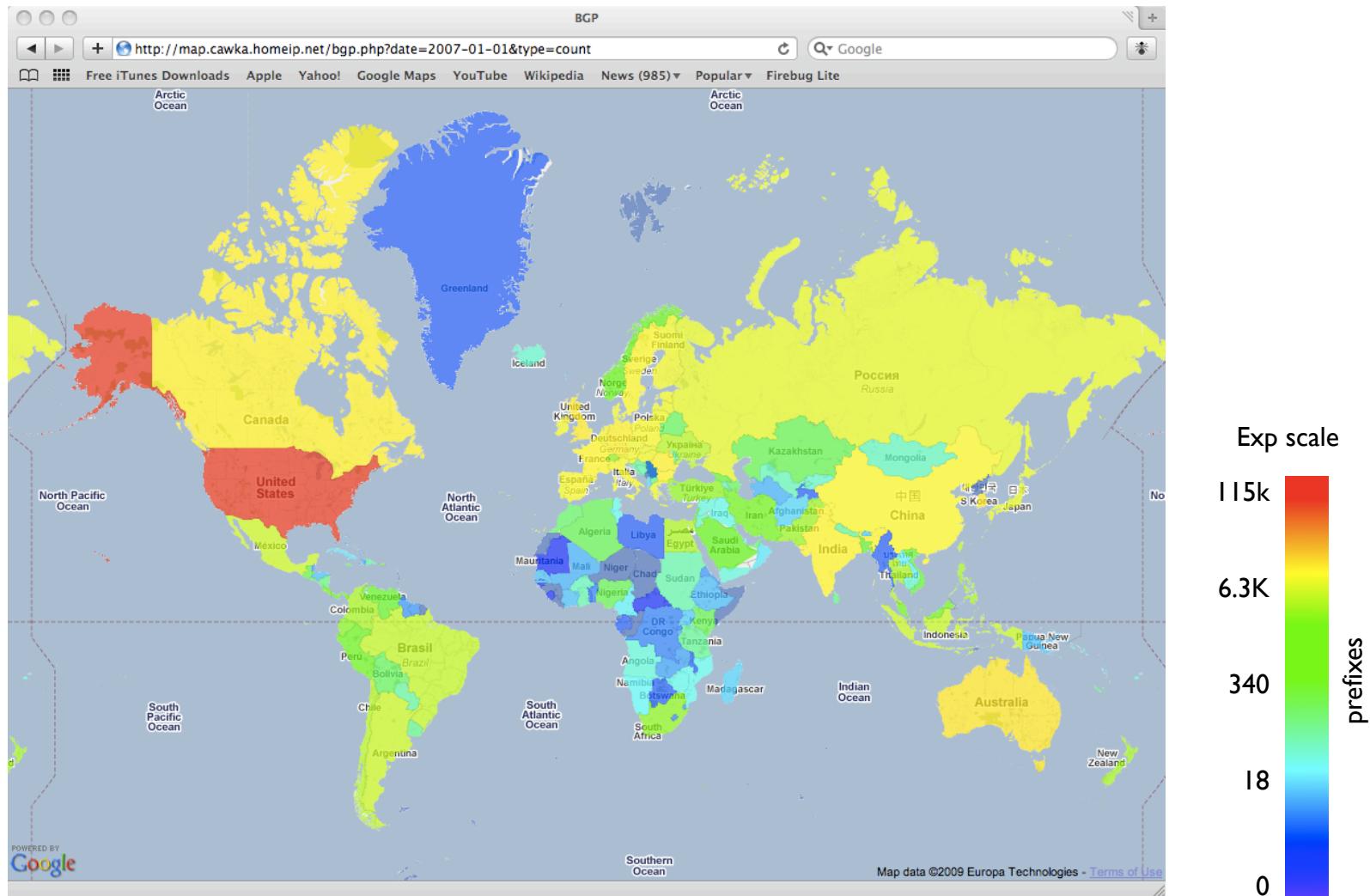
Distribution of BGP announced prefixes **2006**

[4/8]



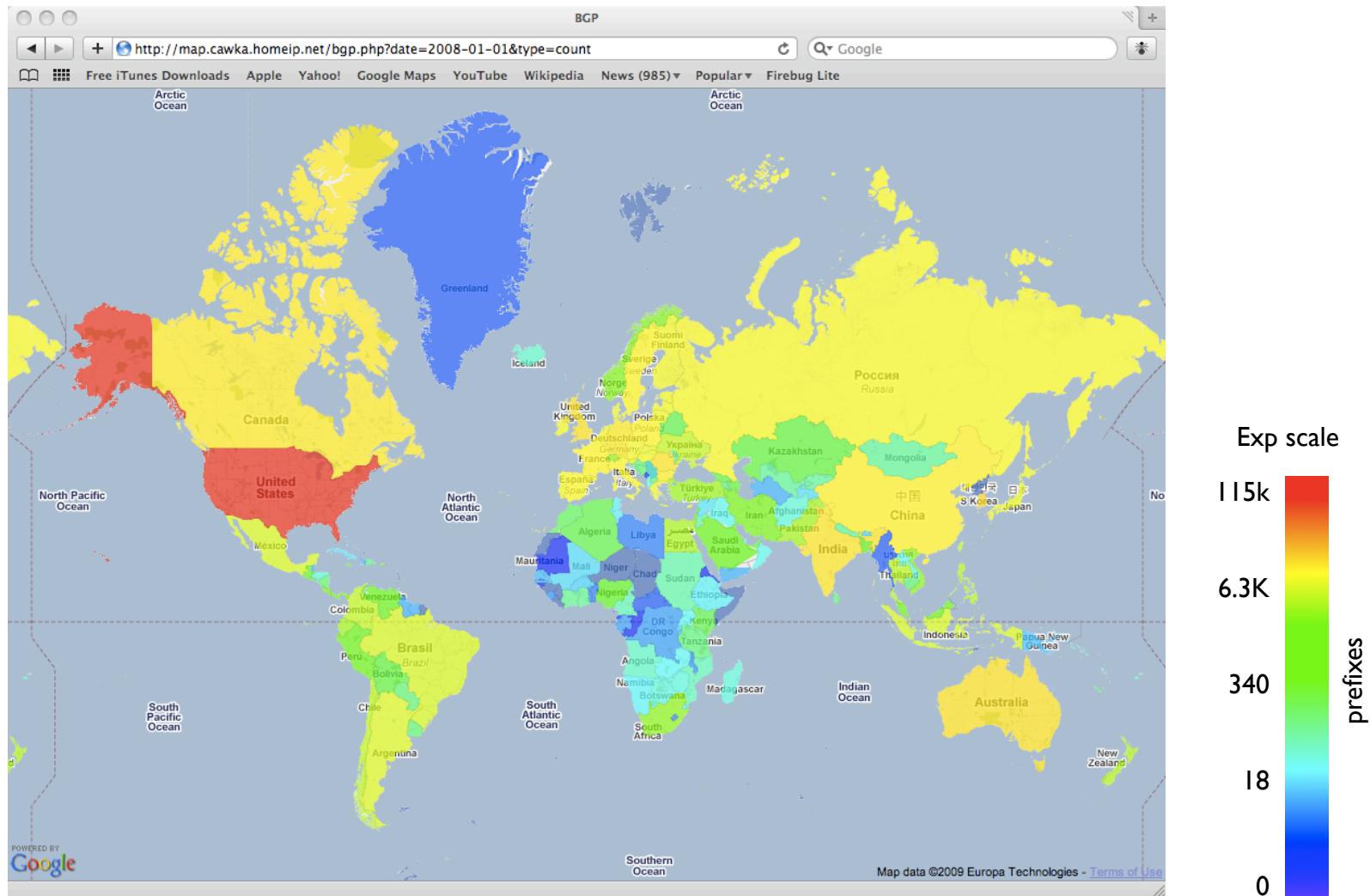
Distribution of BGP announced prefixes **2007**

[5/8]



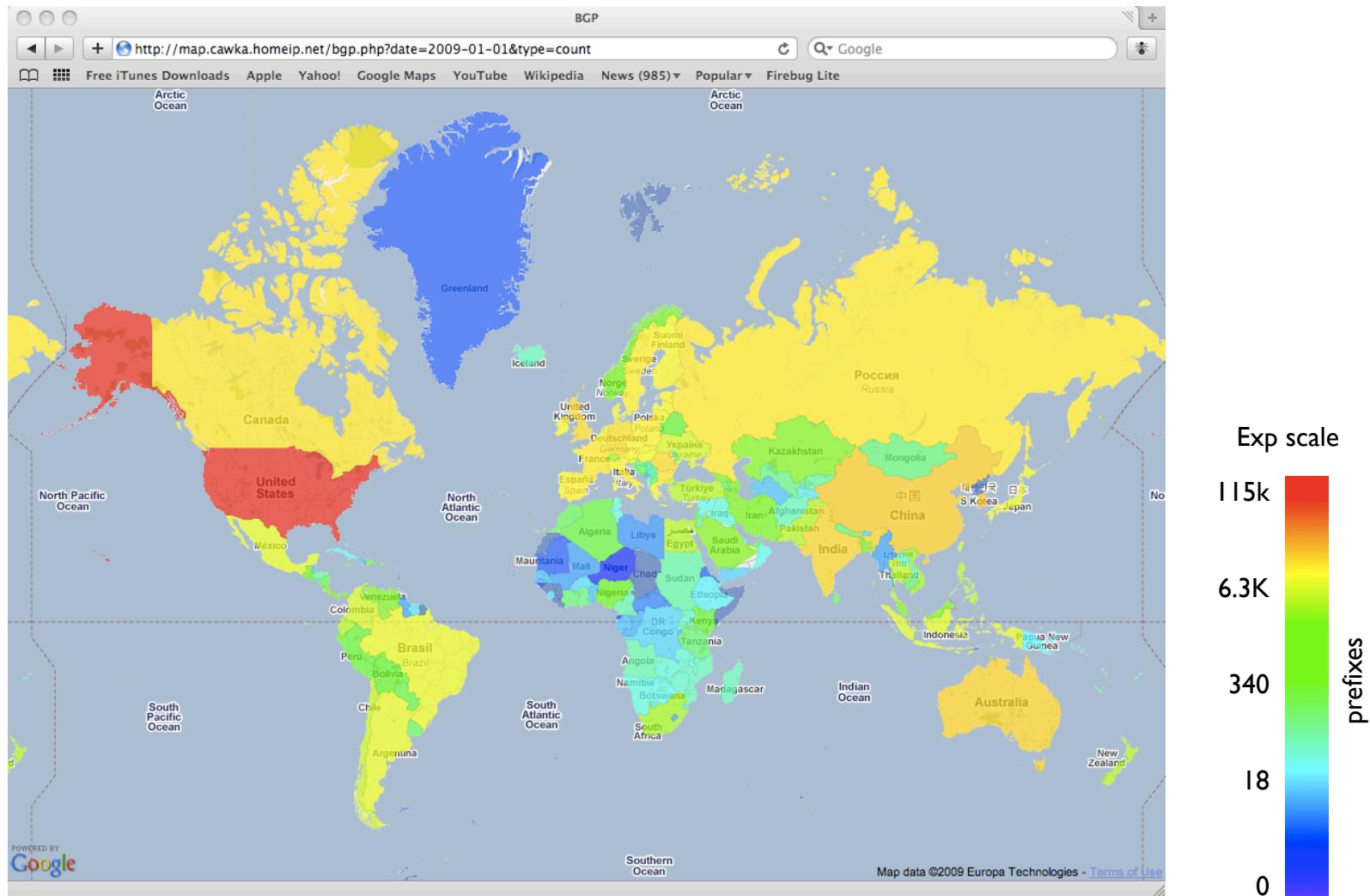
Distribution of BGP announced prefixes **2008**

[6/8]



Distribution of BGP announced prefixes 2009

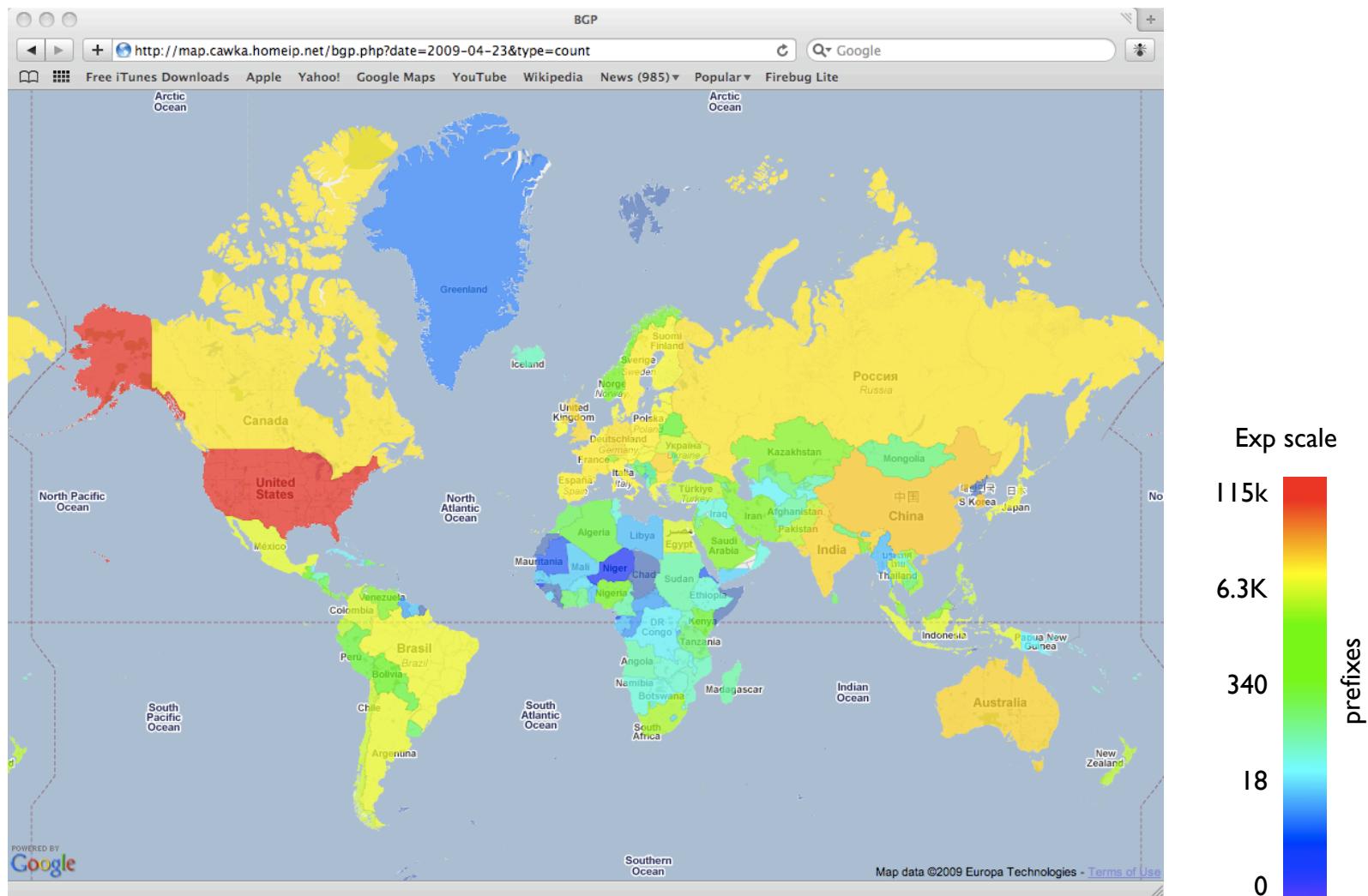
[7/8]



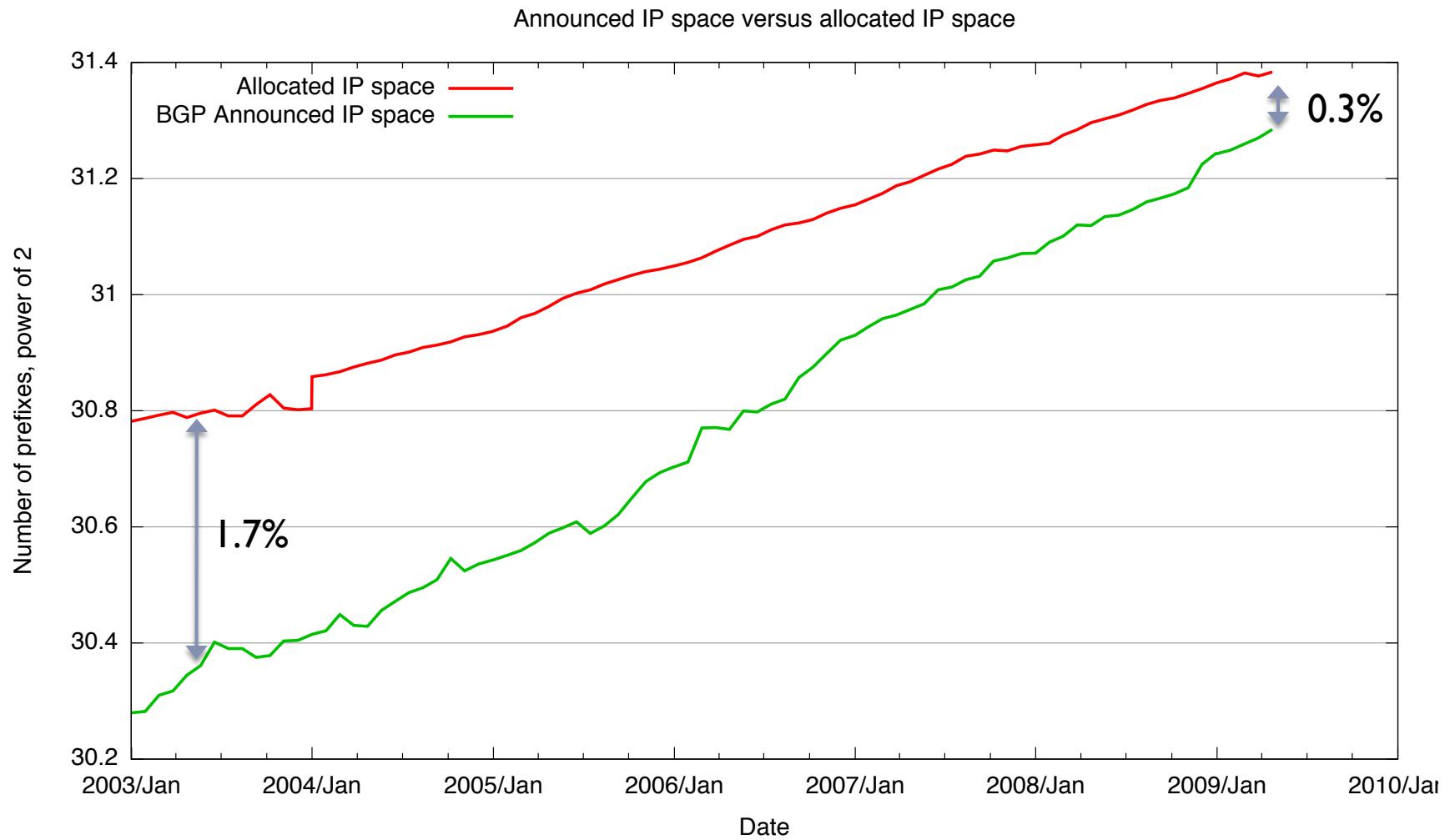
Distribution of BGP announced prefixes

May 2009

[8/8]

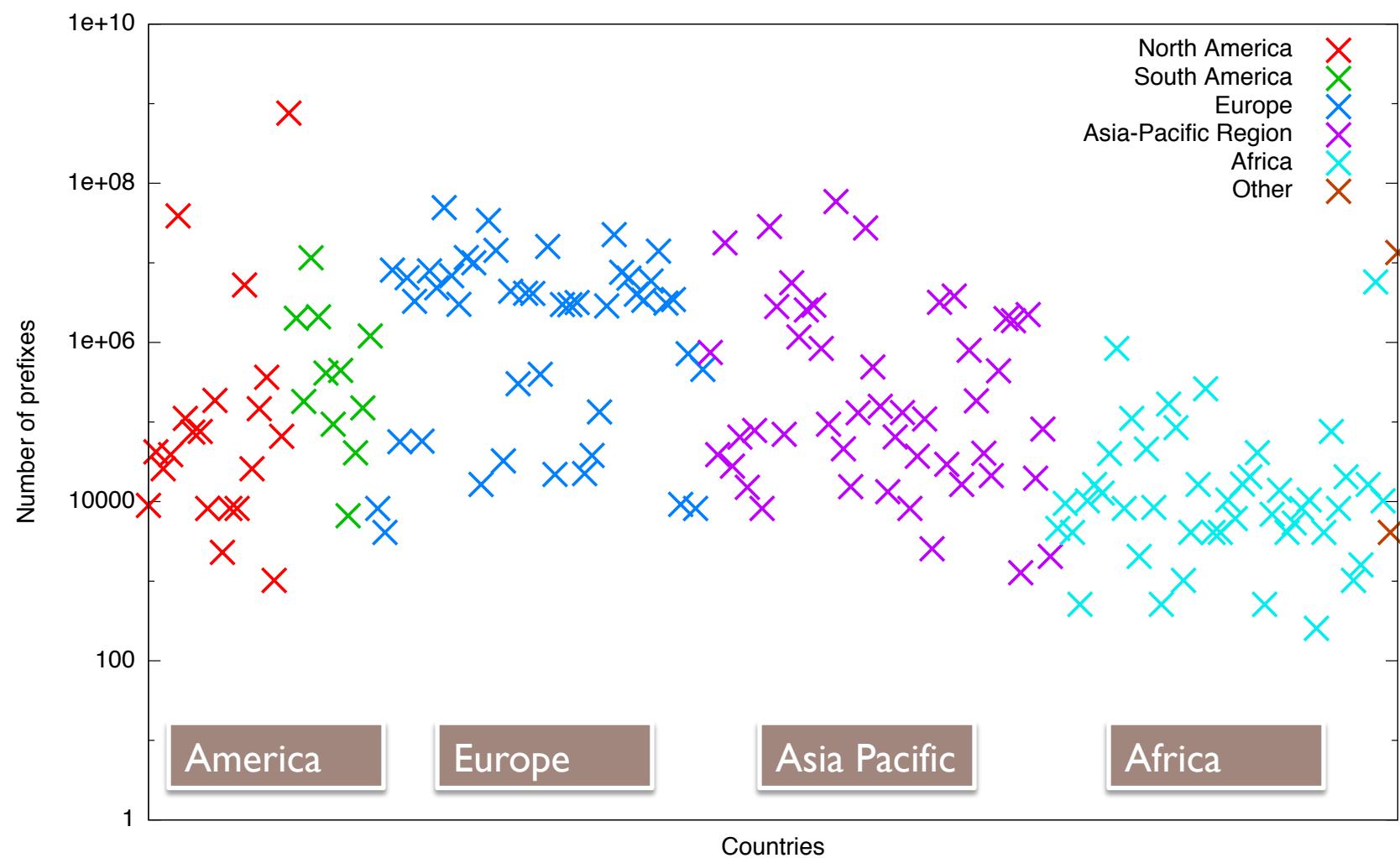


Allocated vs announced IP space

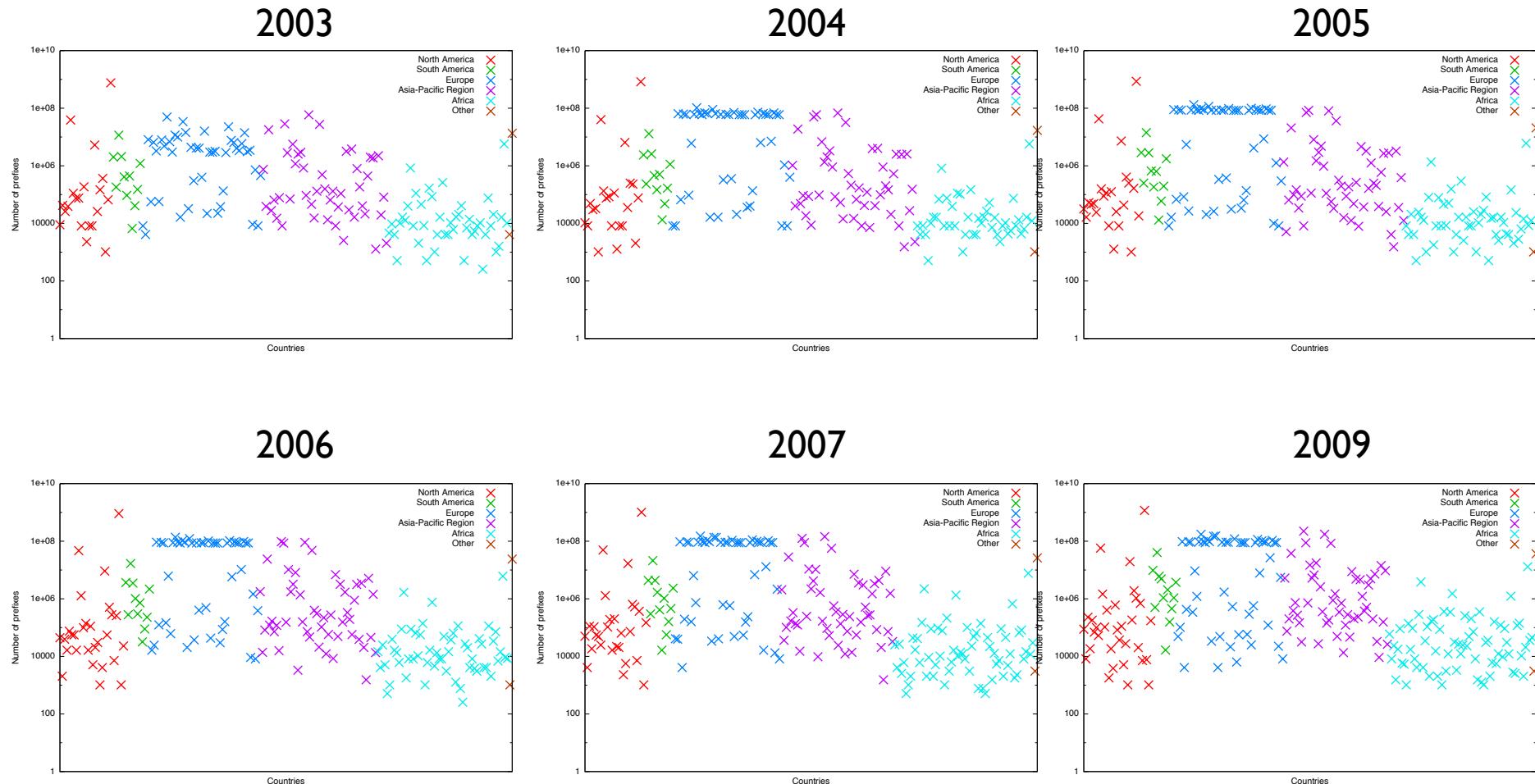


- ▶ I. BGP table doesn't cover all allocated IP space
- 2. There are globally unused IPs

Distribution of announced IP space in 2003



Distribution of announced IP space



► 20

General trend - growth of used IP space globally

Distribution of announced IP space **2003**

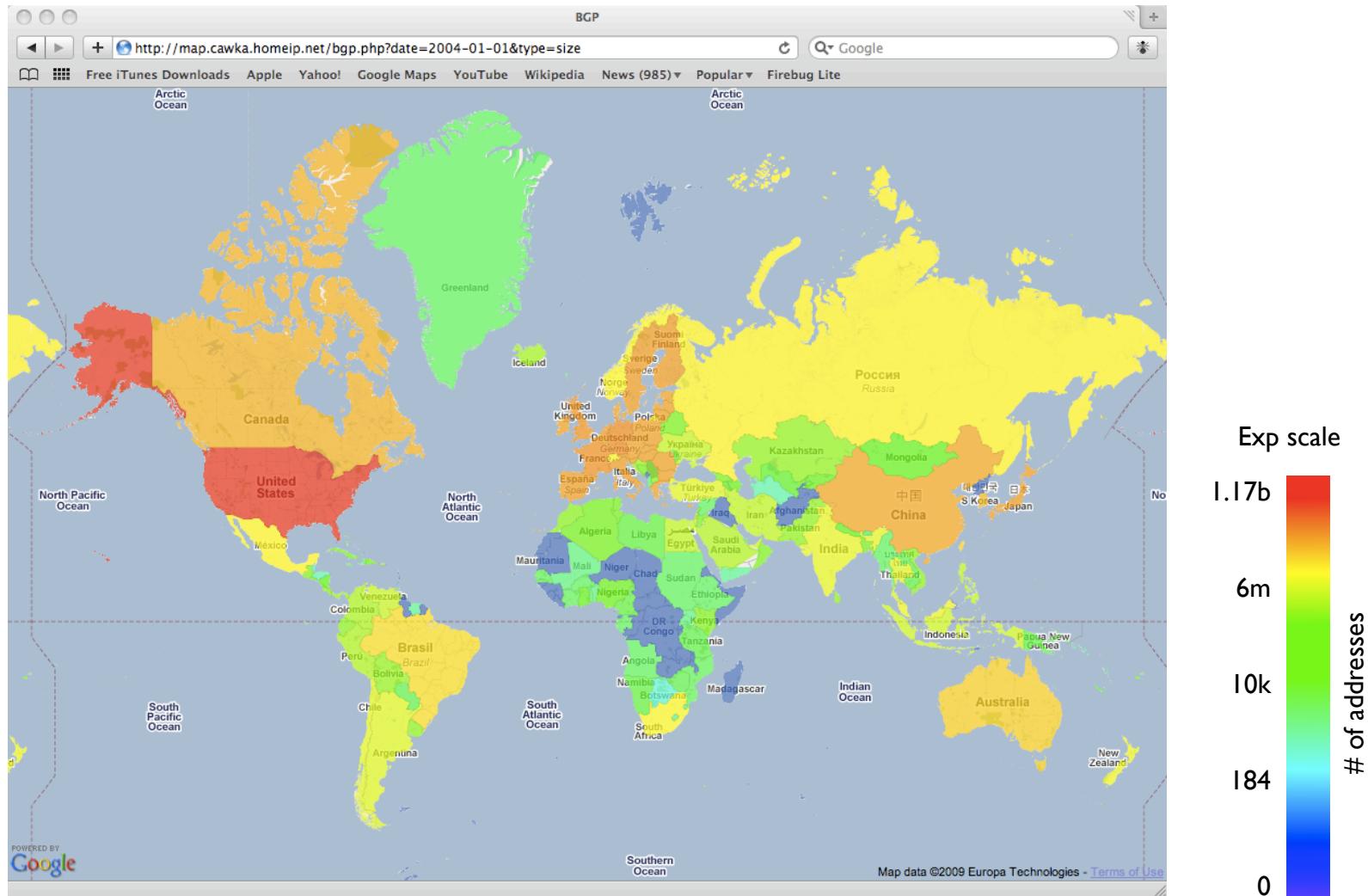
[1 / 8]



Distribution of announced IP space

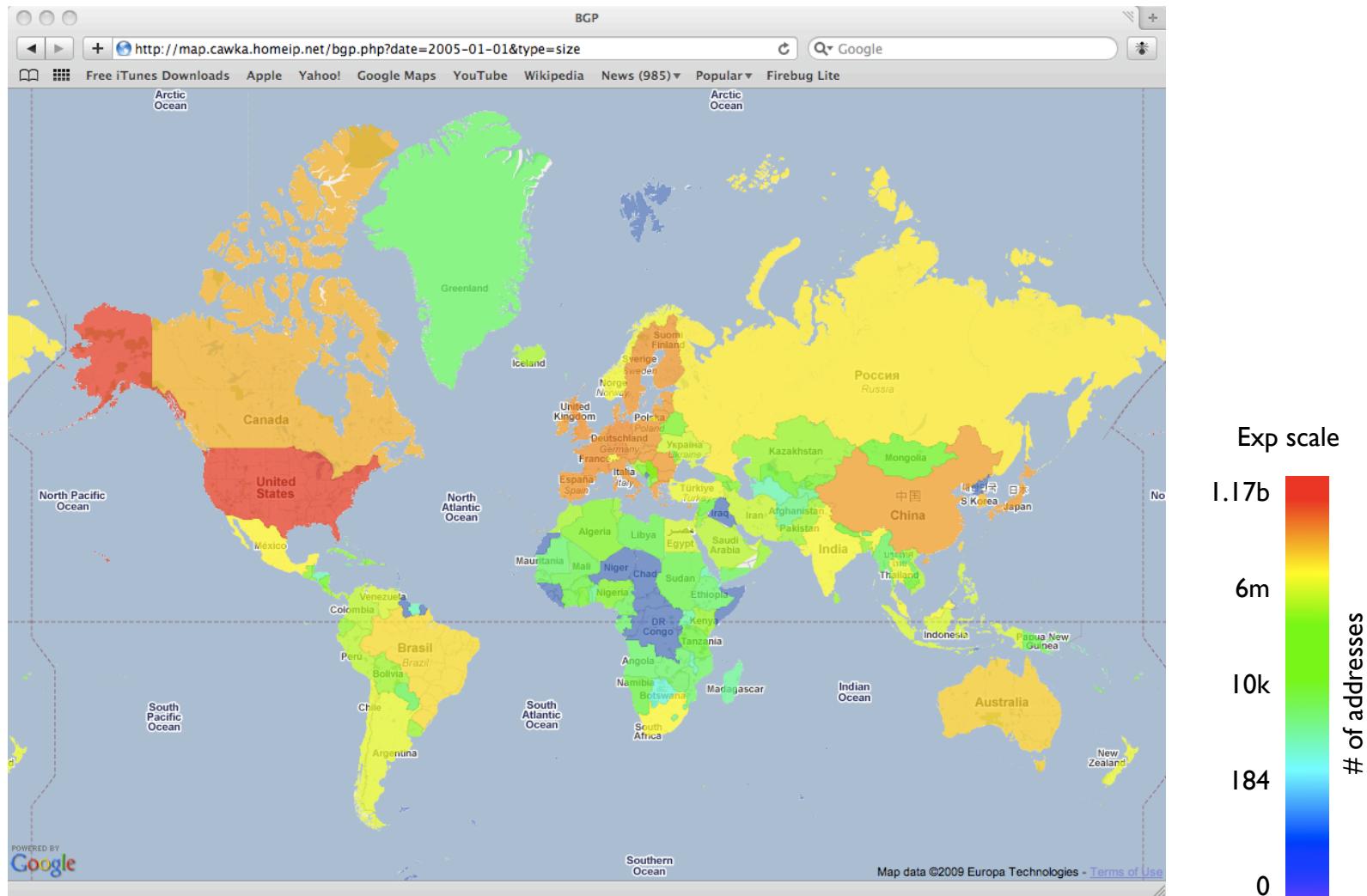
2004

[2/8]



Distribution of announced IP space **2005**

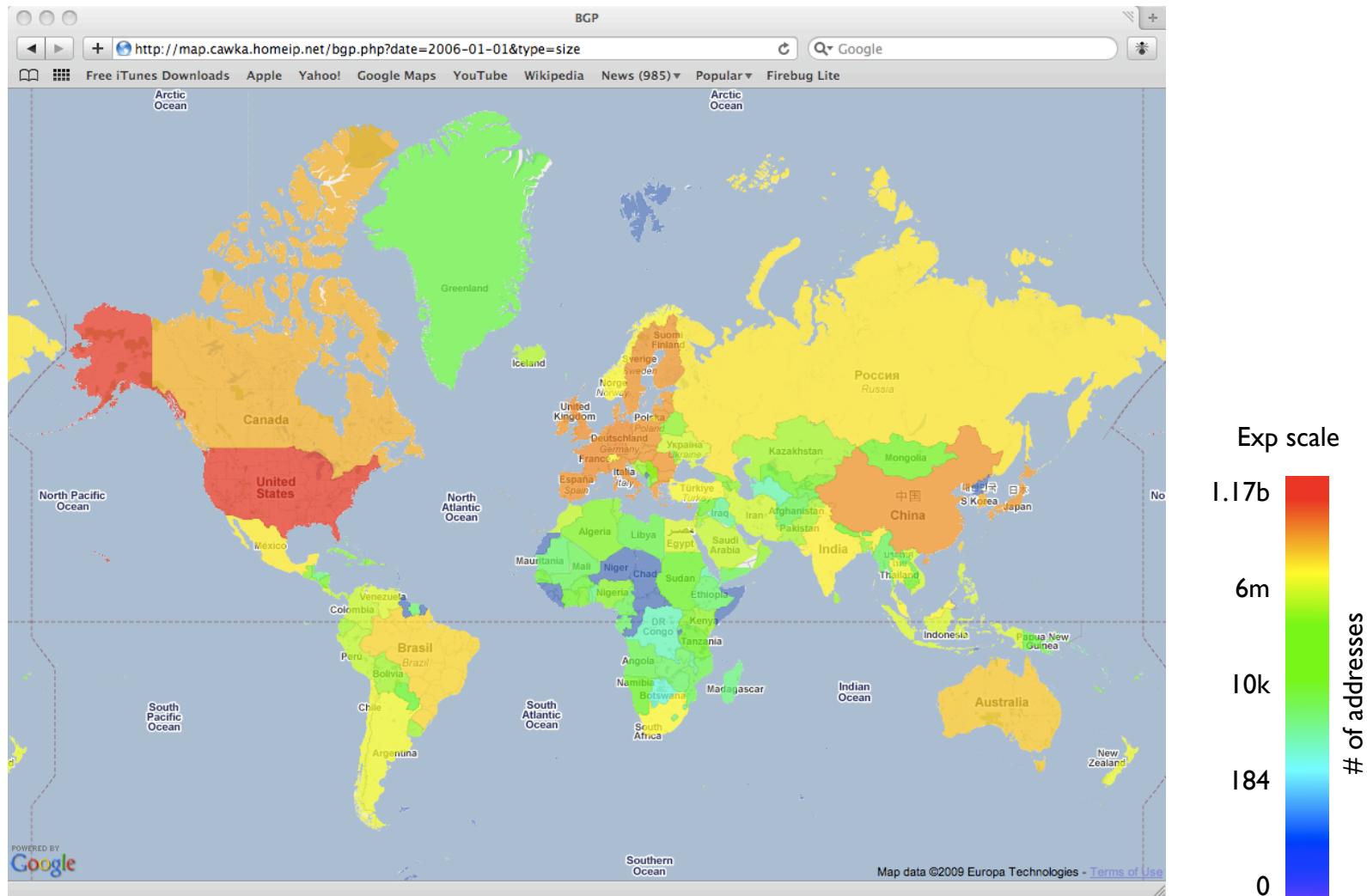
[3/8]



Distribution of announced IP space

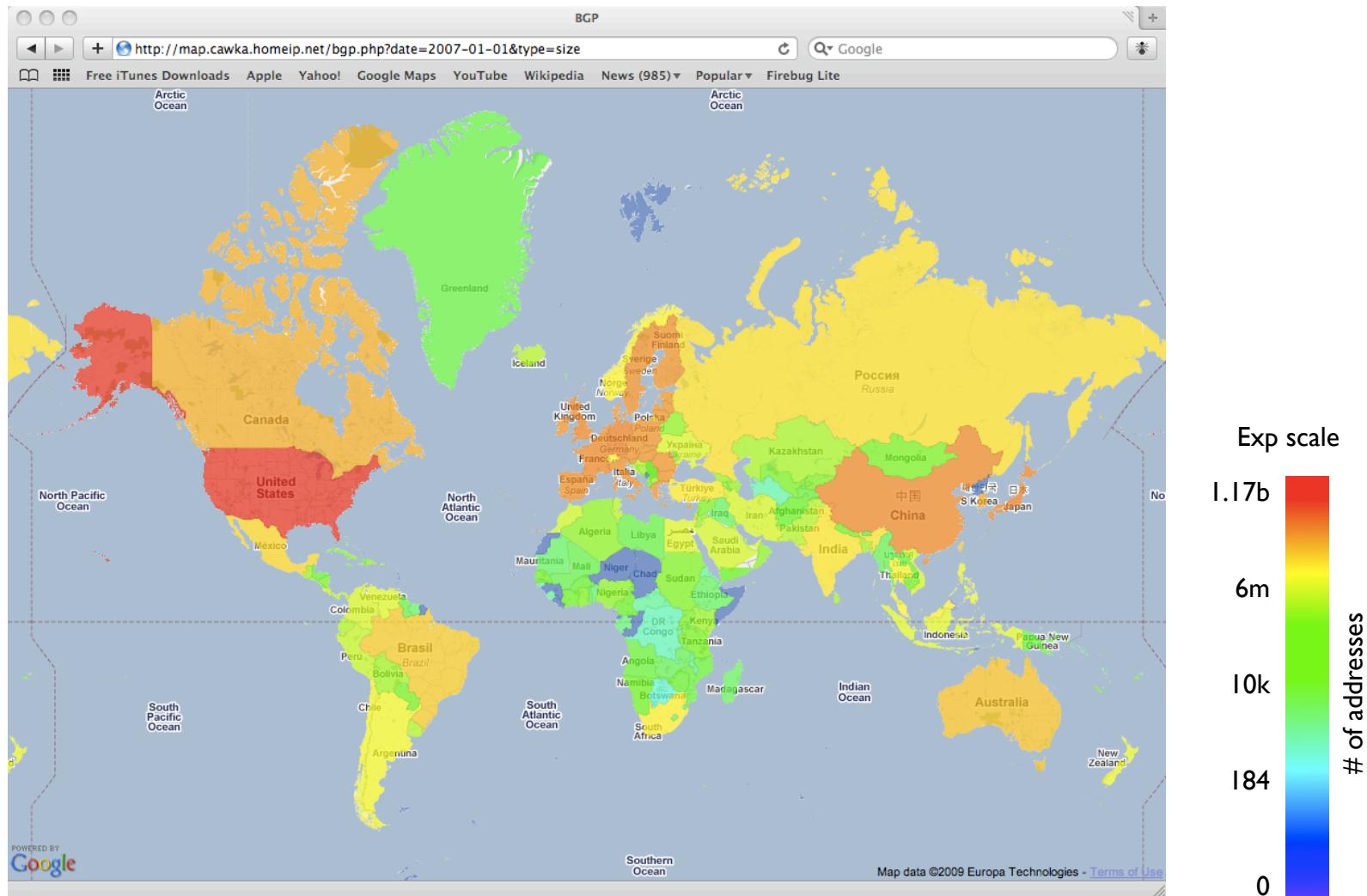
2006

[4/8]



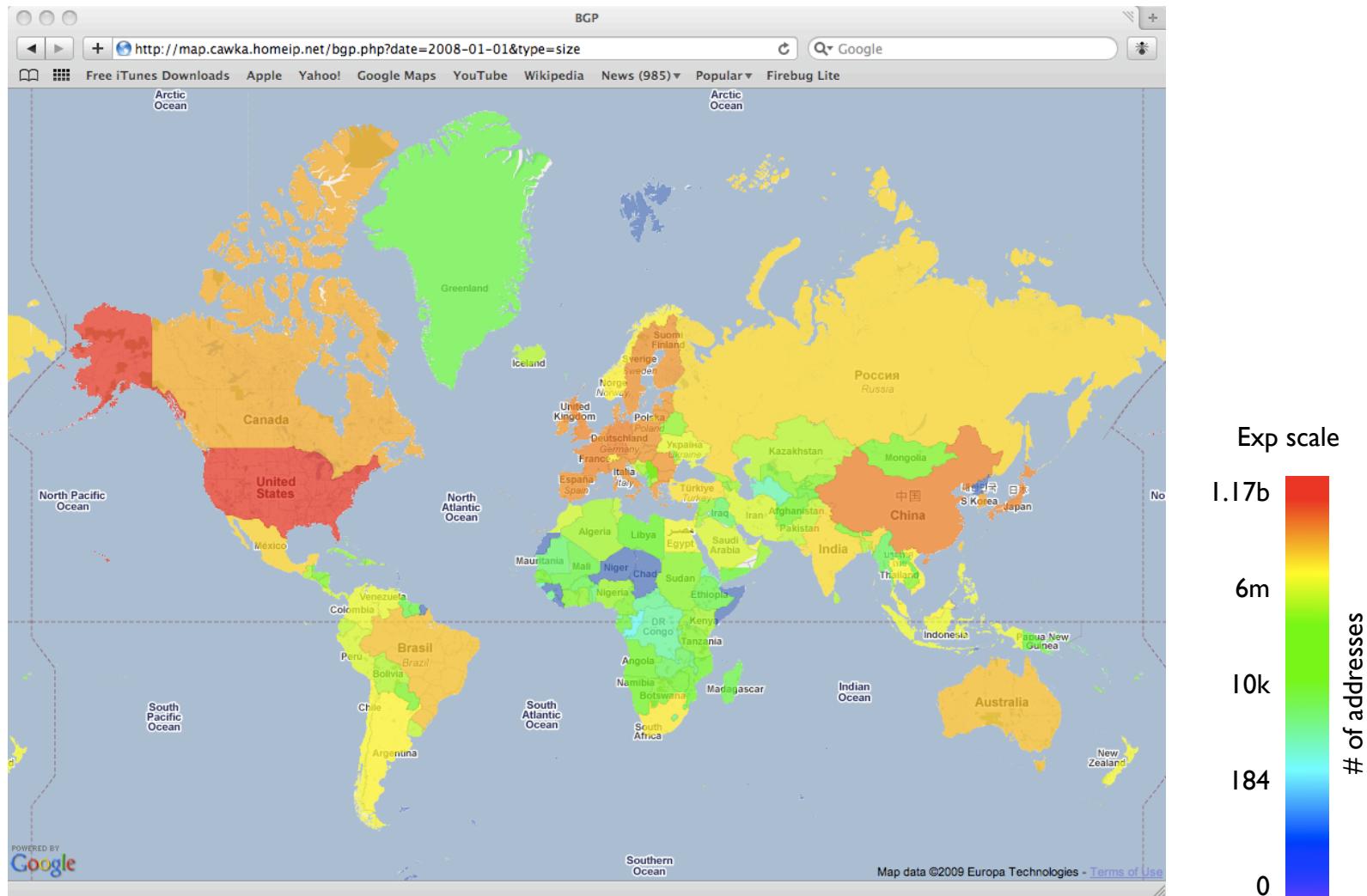
Distribution of announced IP space **2007**

[5/8]



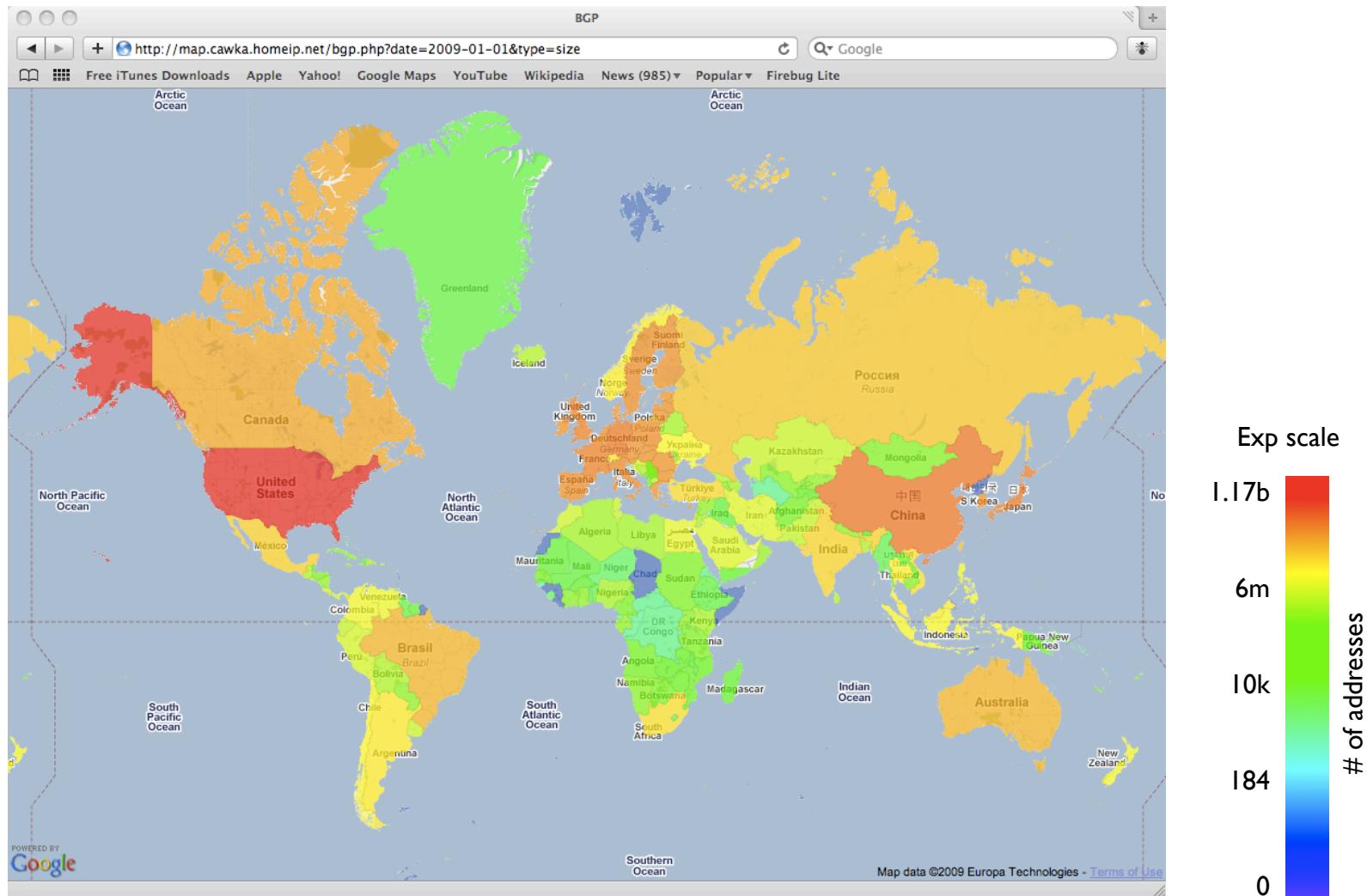
Distribution of announced IP space **2008**

[6/8]



Distribution of announced IP space **2009**

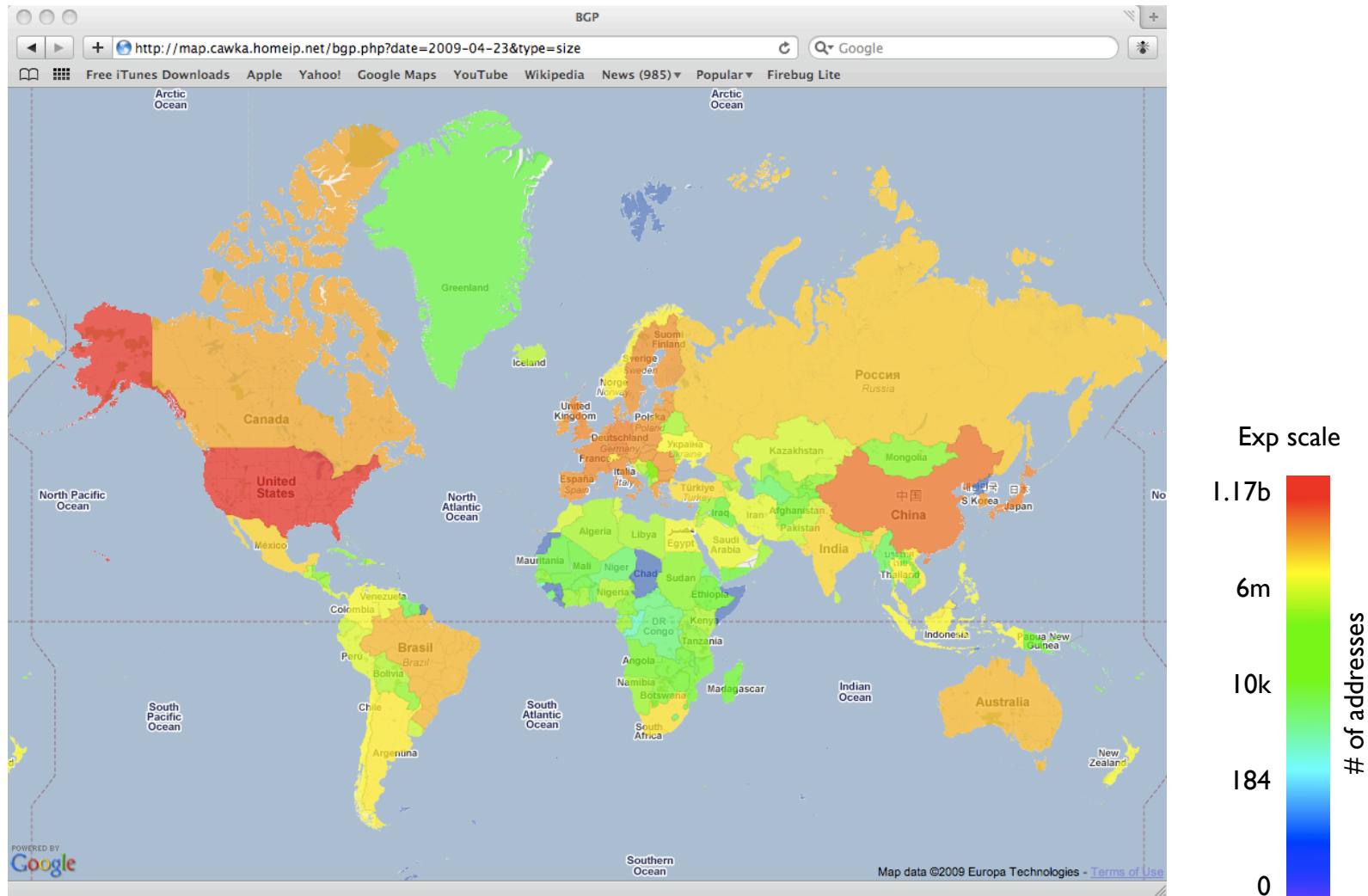
[7/8]



Distribution of announced IP space

May 2009

[8/8]

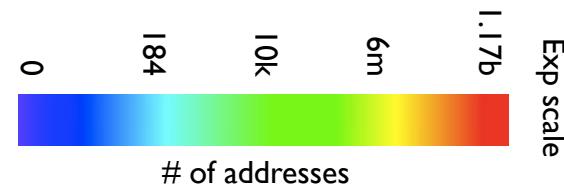
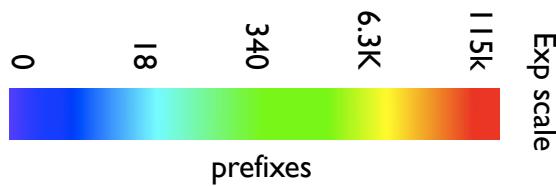


Number of prefixes versus IP space

Number of prefixes

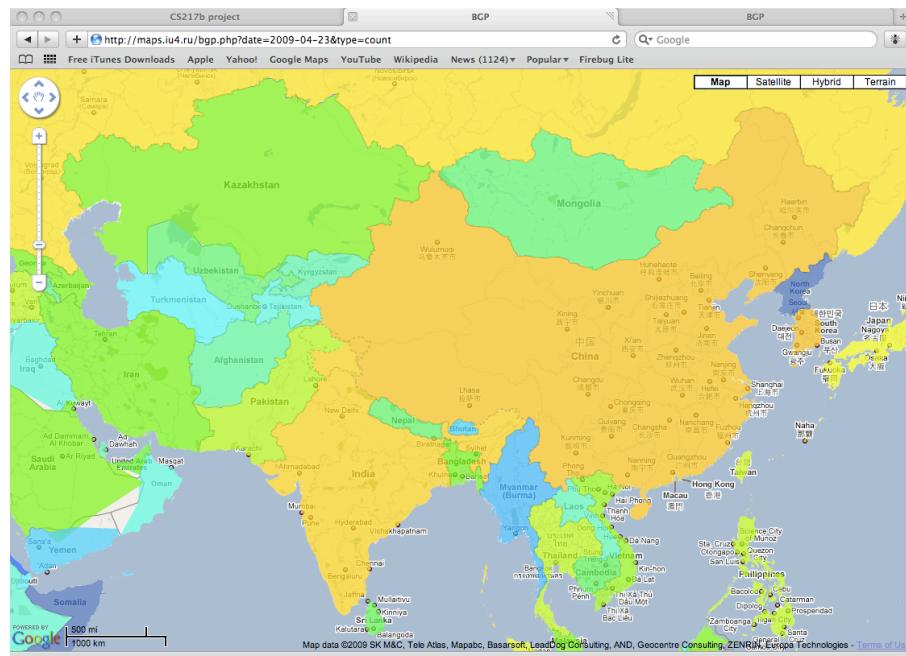


IP space

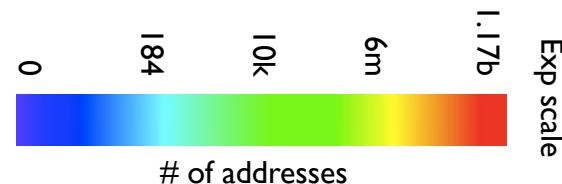
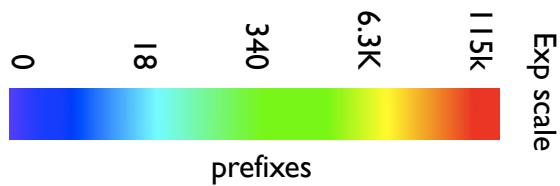
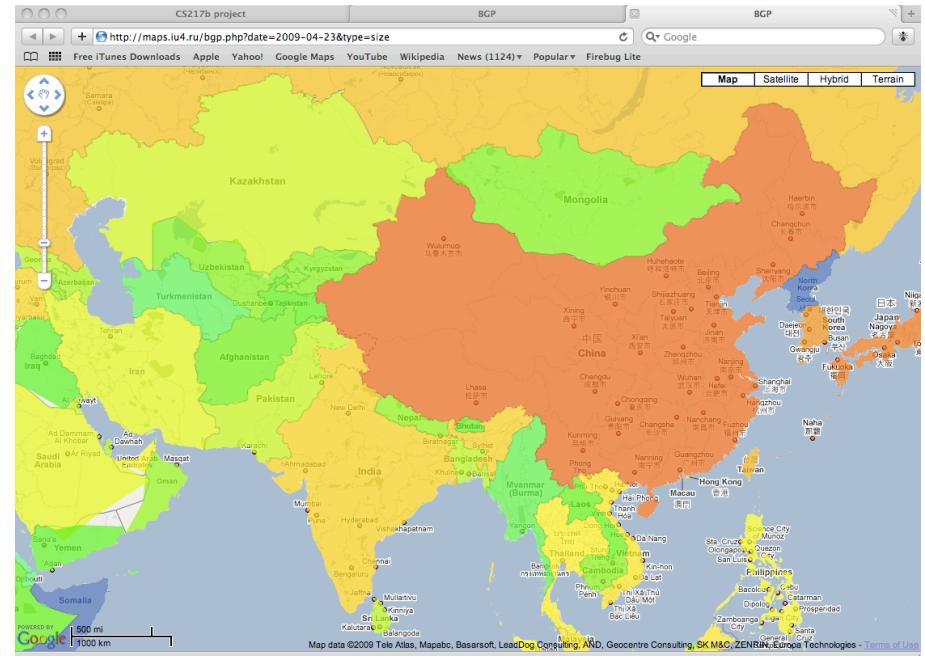


Number of prefixes versus IP space

Number of prefixes

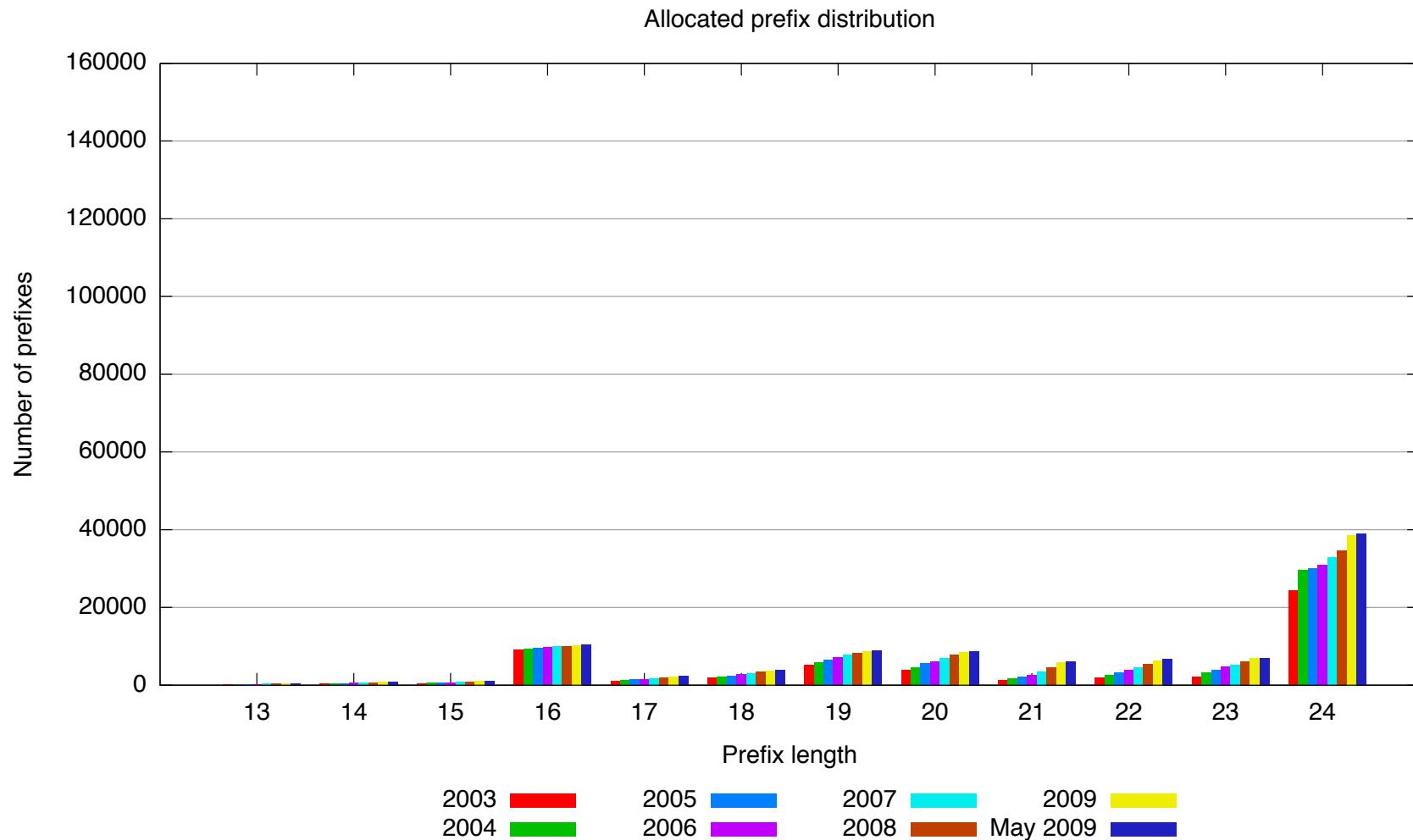


IP space



Distribution of prefix lengths

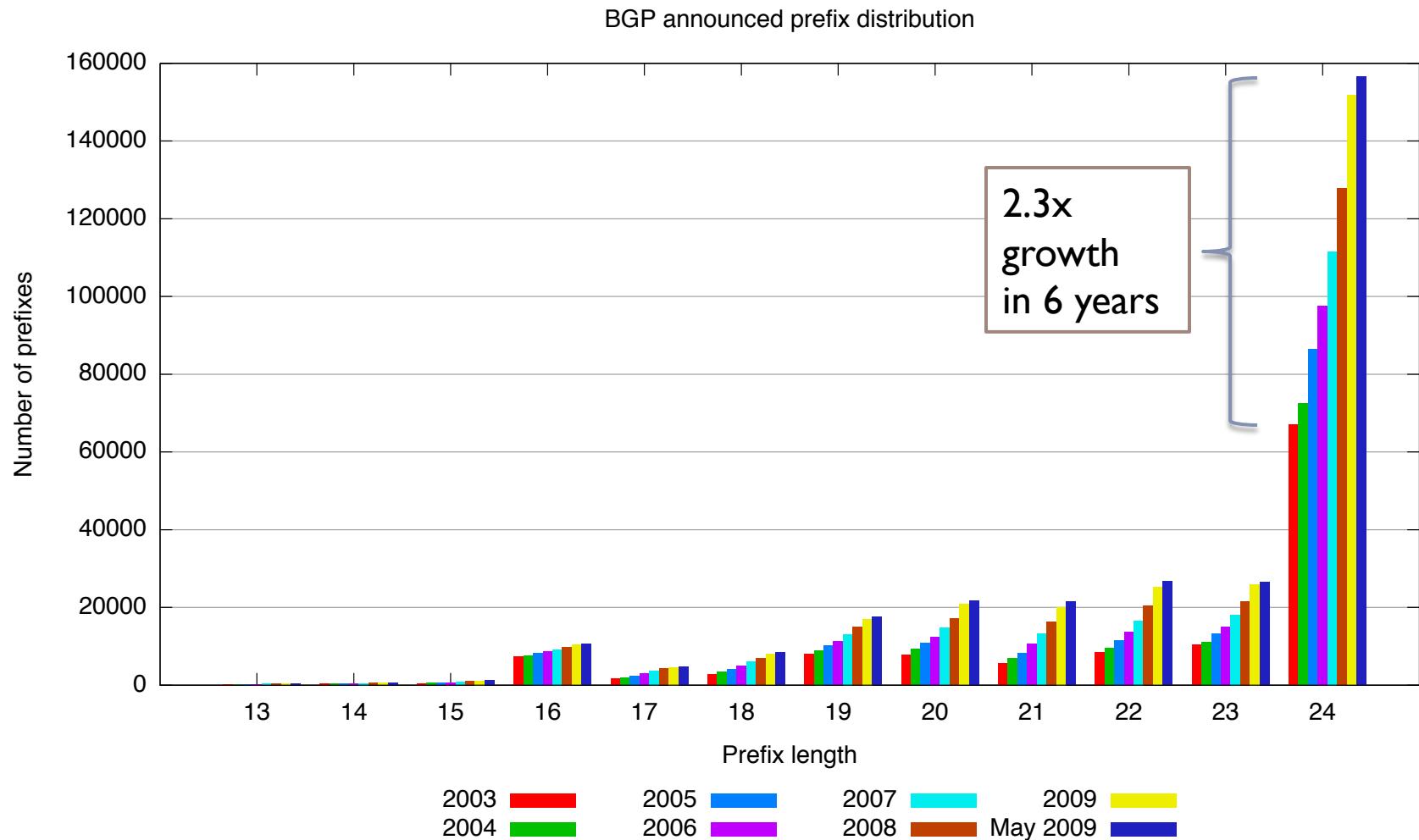
IP allocations



► 31 Most of IP allocations are /24 blocks
Big number of allocations of /16, /19 and /20 blocks

Distribution of prefix lengths

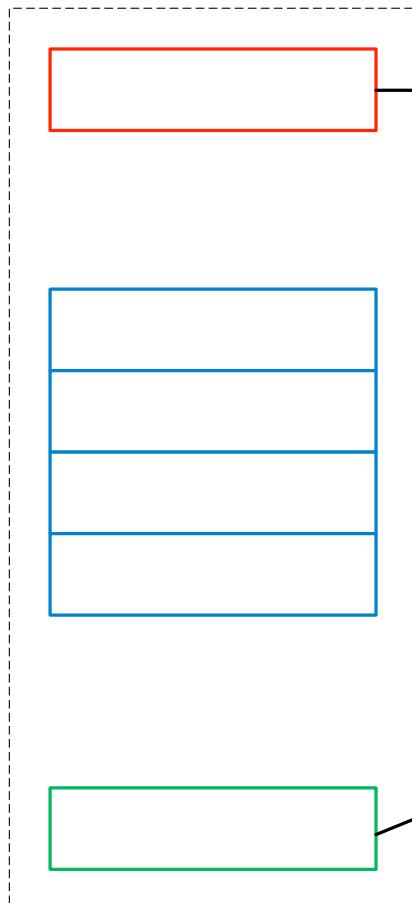
BGP announcements



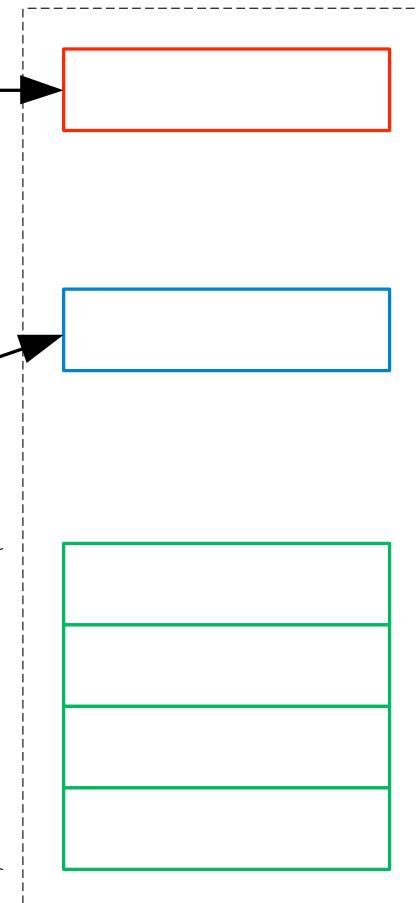
► 32 Most of BGP entries are /24 blocks - 50%
/16, /19, /20, /21, /22 and /23 - the rest of 50%

Some definitions

IP allocations



BGP table entries

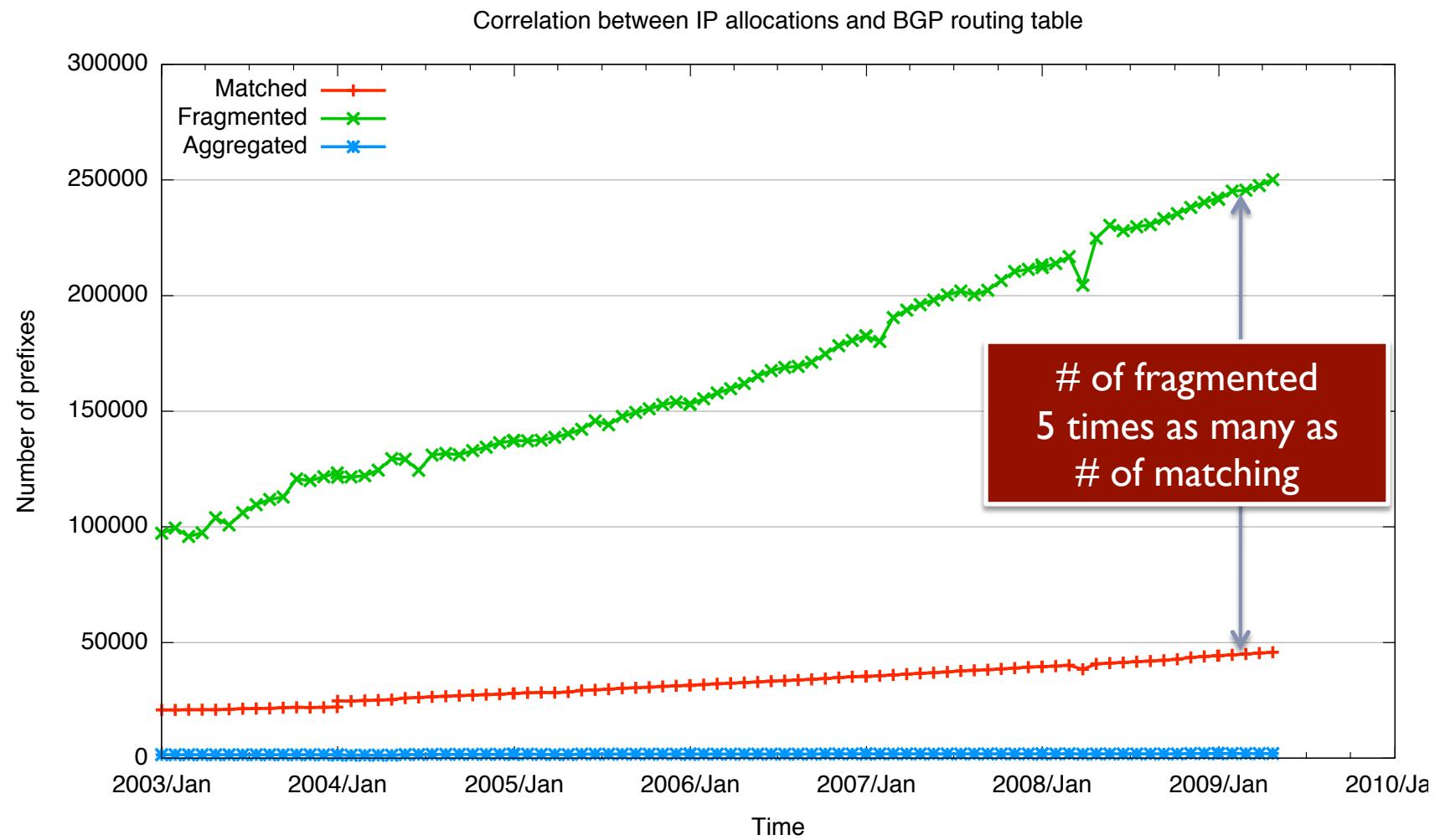


Matched

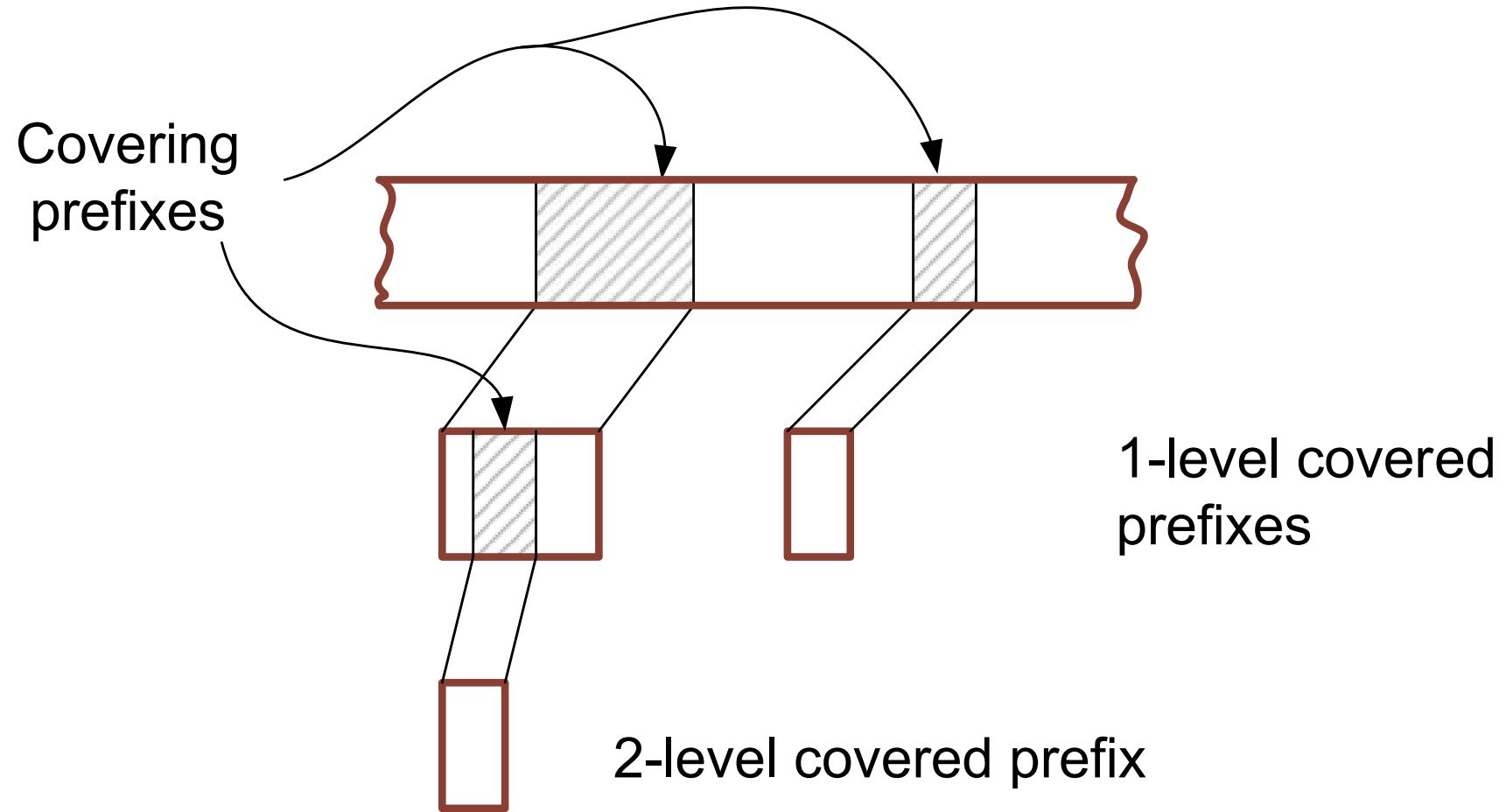
Aggregated

Fragmented

Impact of the fragmentation on the BGP routing table size

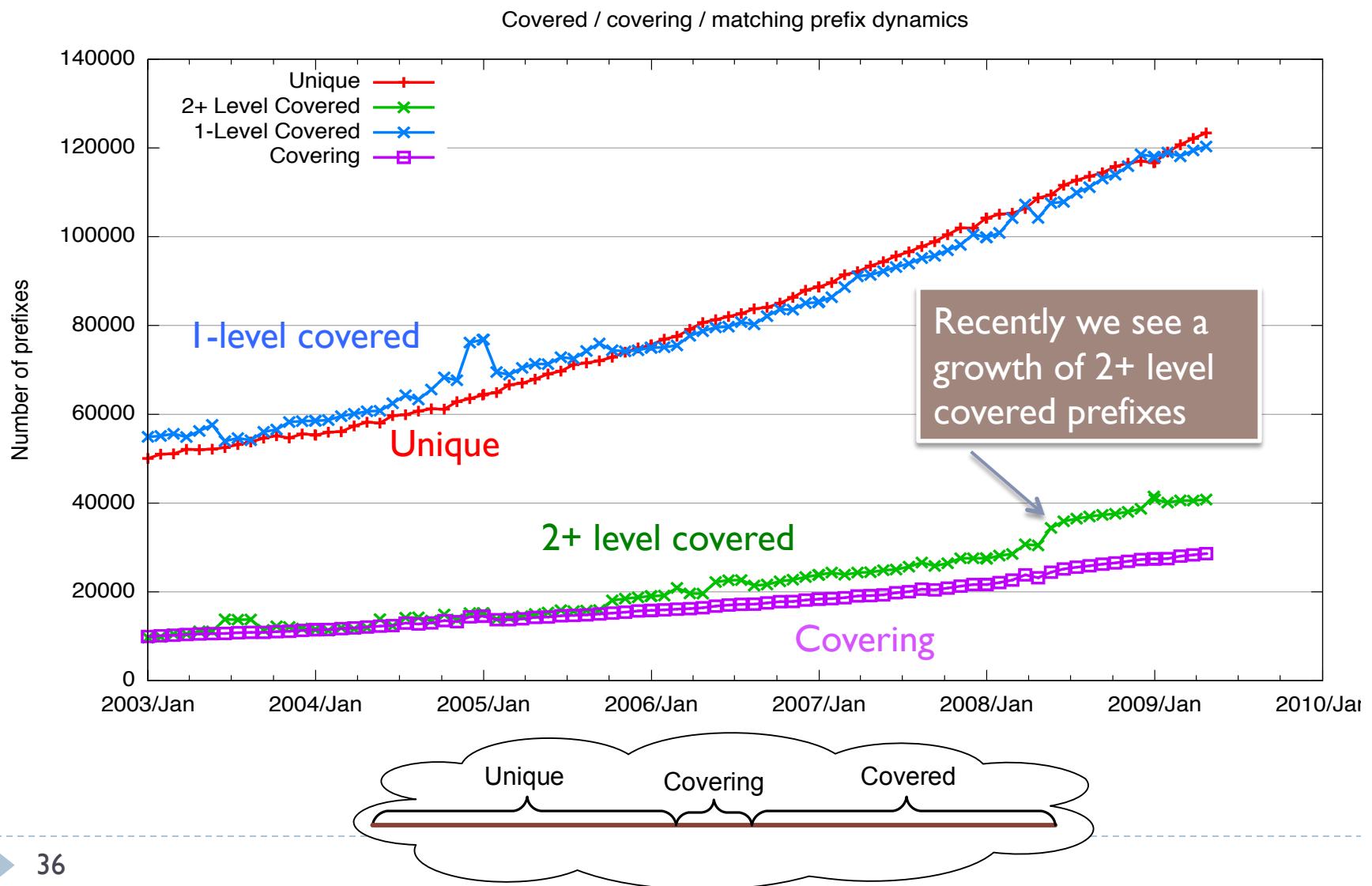


Another bunch of definitions

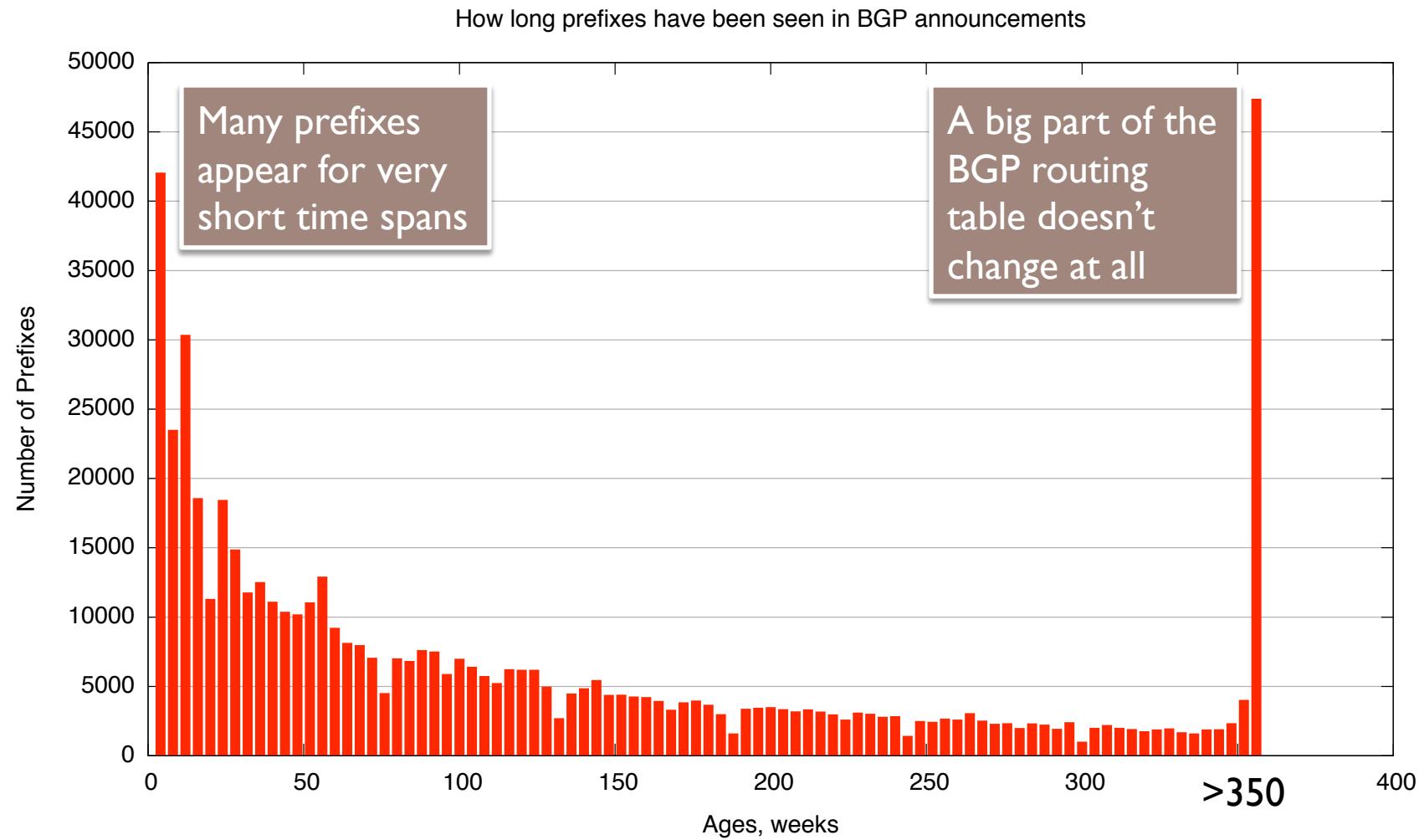


Duplication in BGP routing table

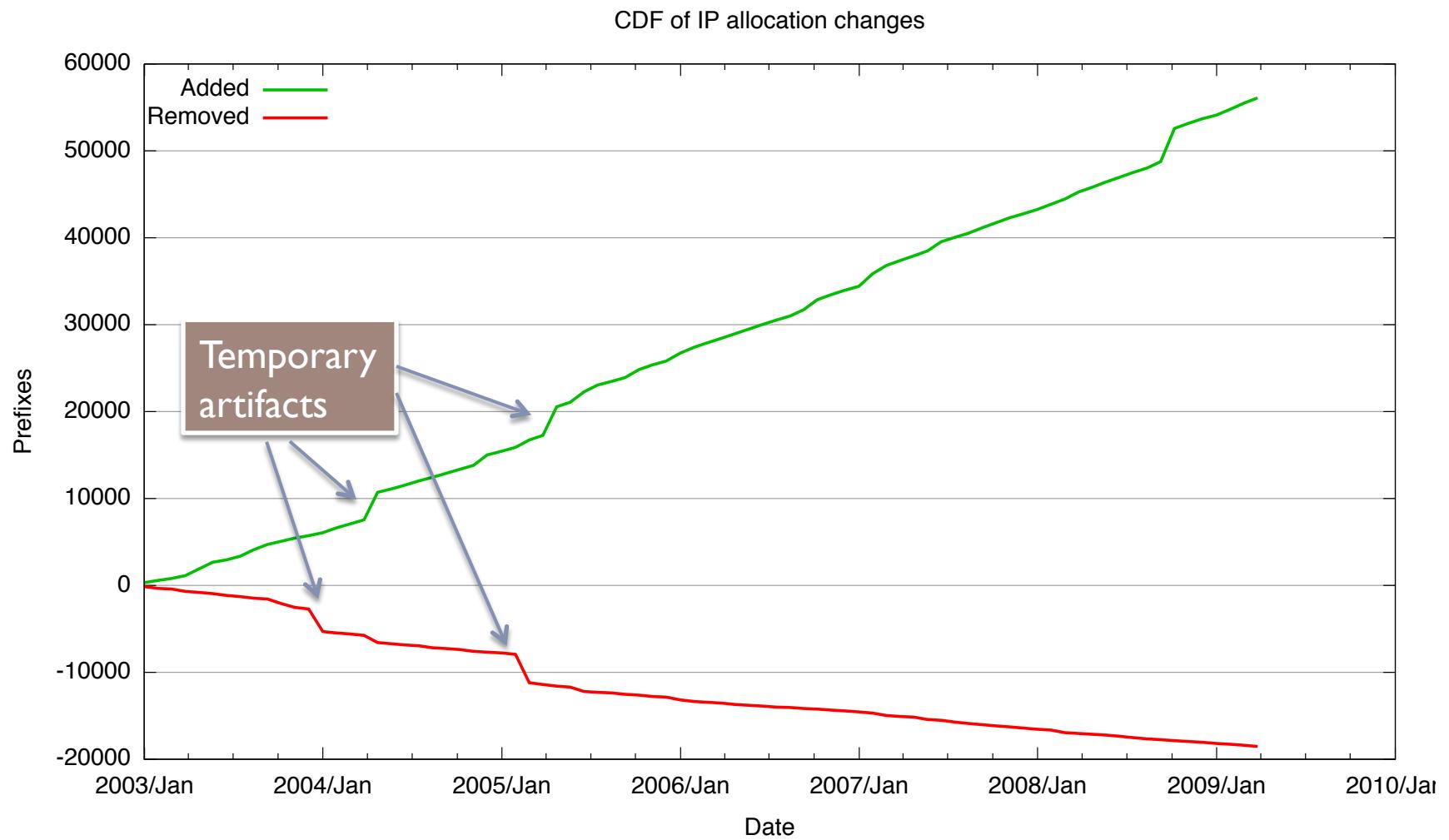
Unique, Covered and Covering prefixes



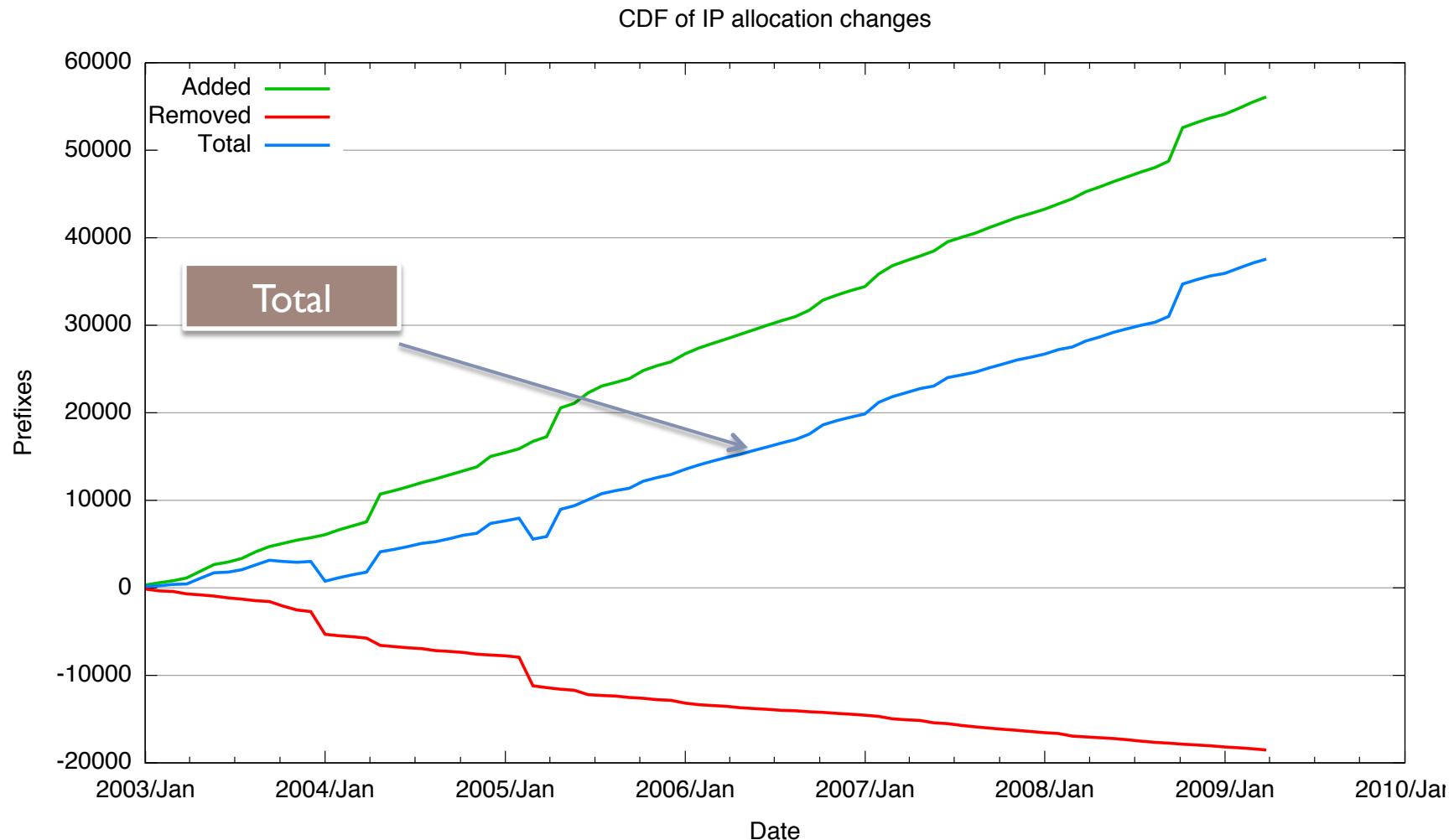
Longevity of BGP announcements



IP allocation and IP deallocation dynamics



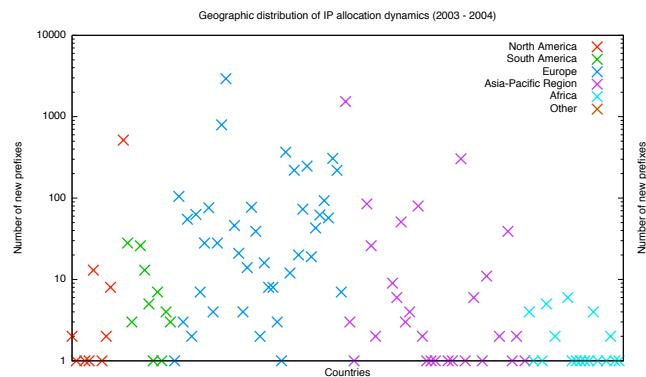
Resulting trends in IP prefix allocation



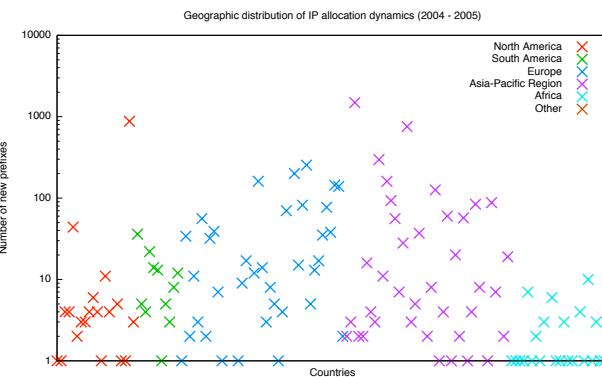
Fewer deallocations than allocations

Year-on-year IP allocation changes by region

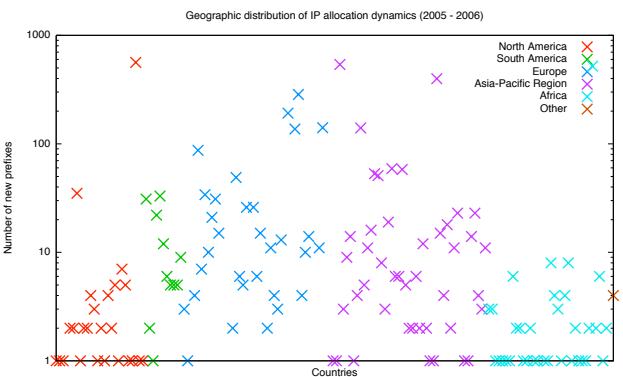
2003-2004



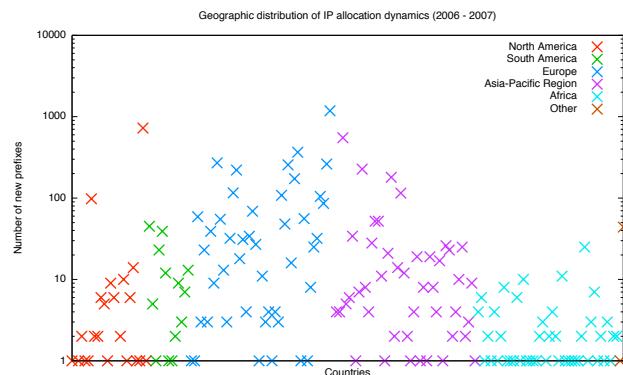
2004-2005



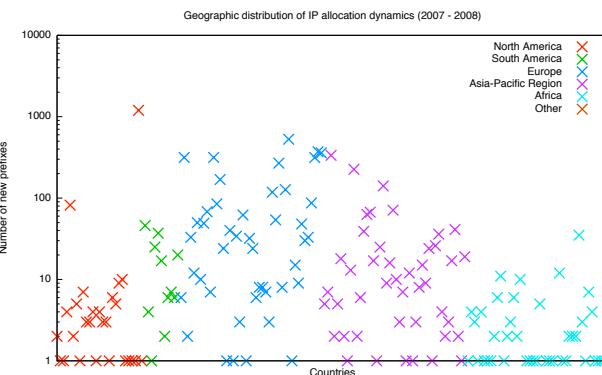
2005-2006



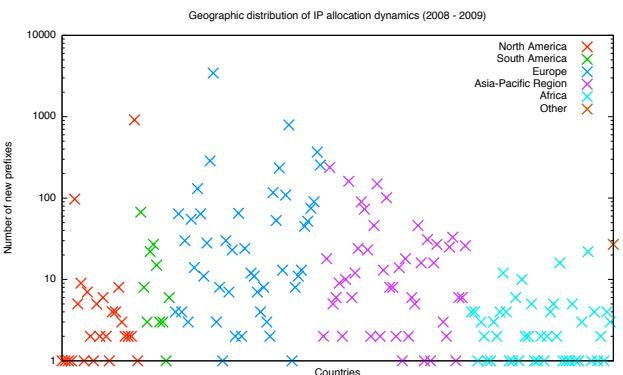
2006-2007



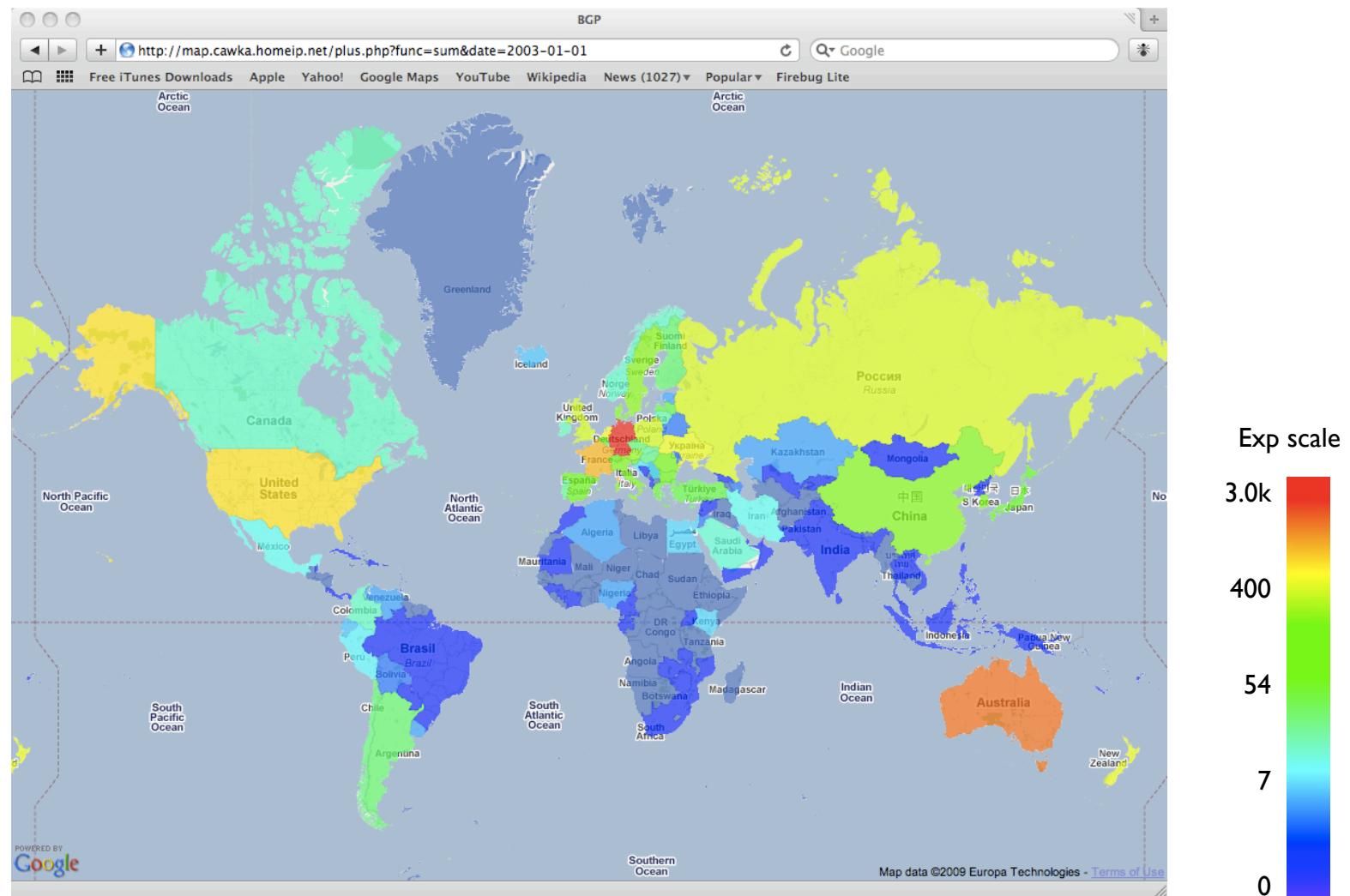
2007-2008



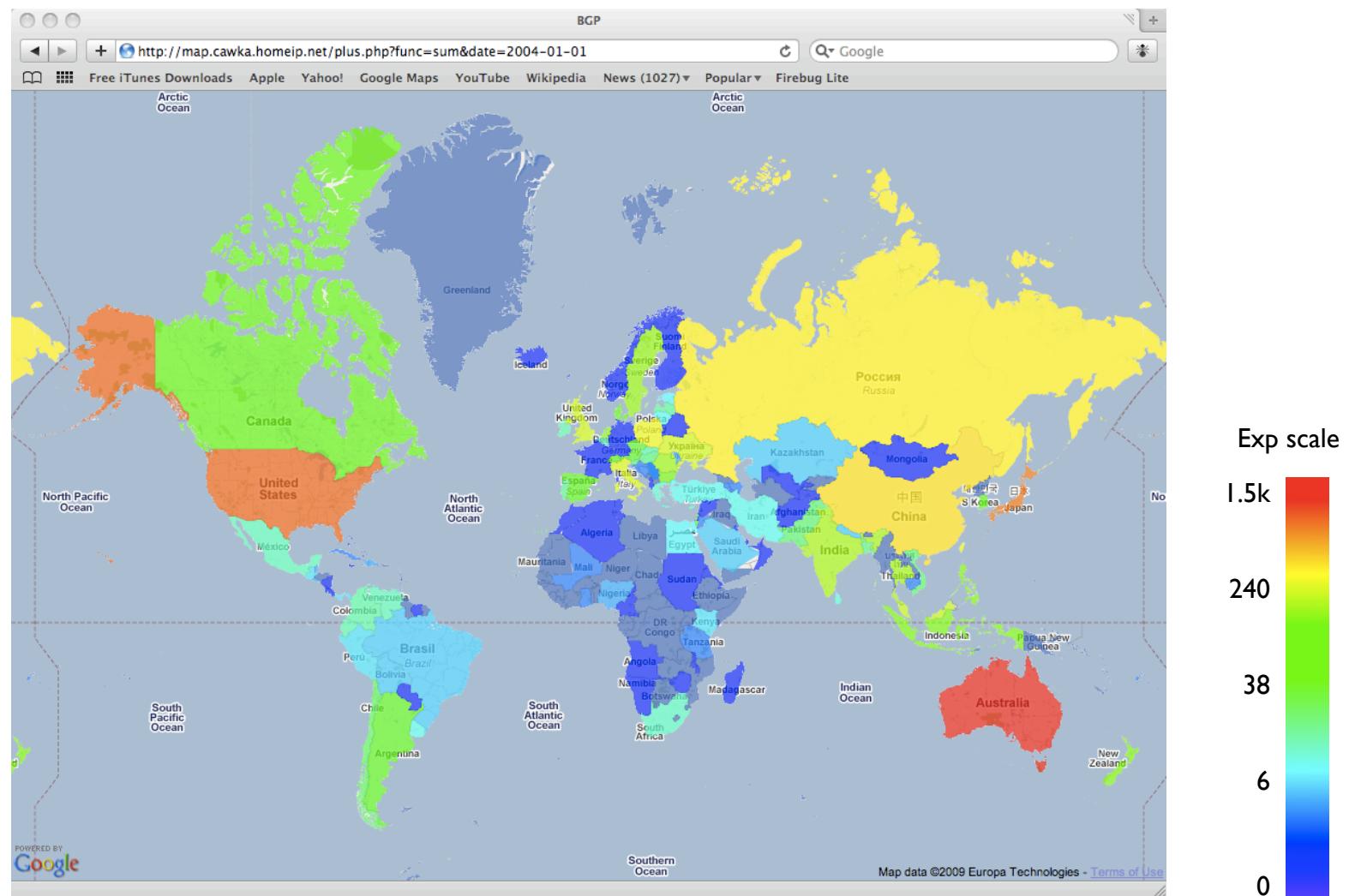
2008-2009



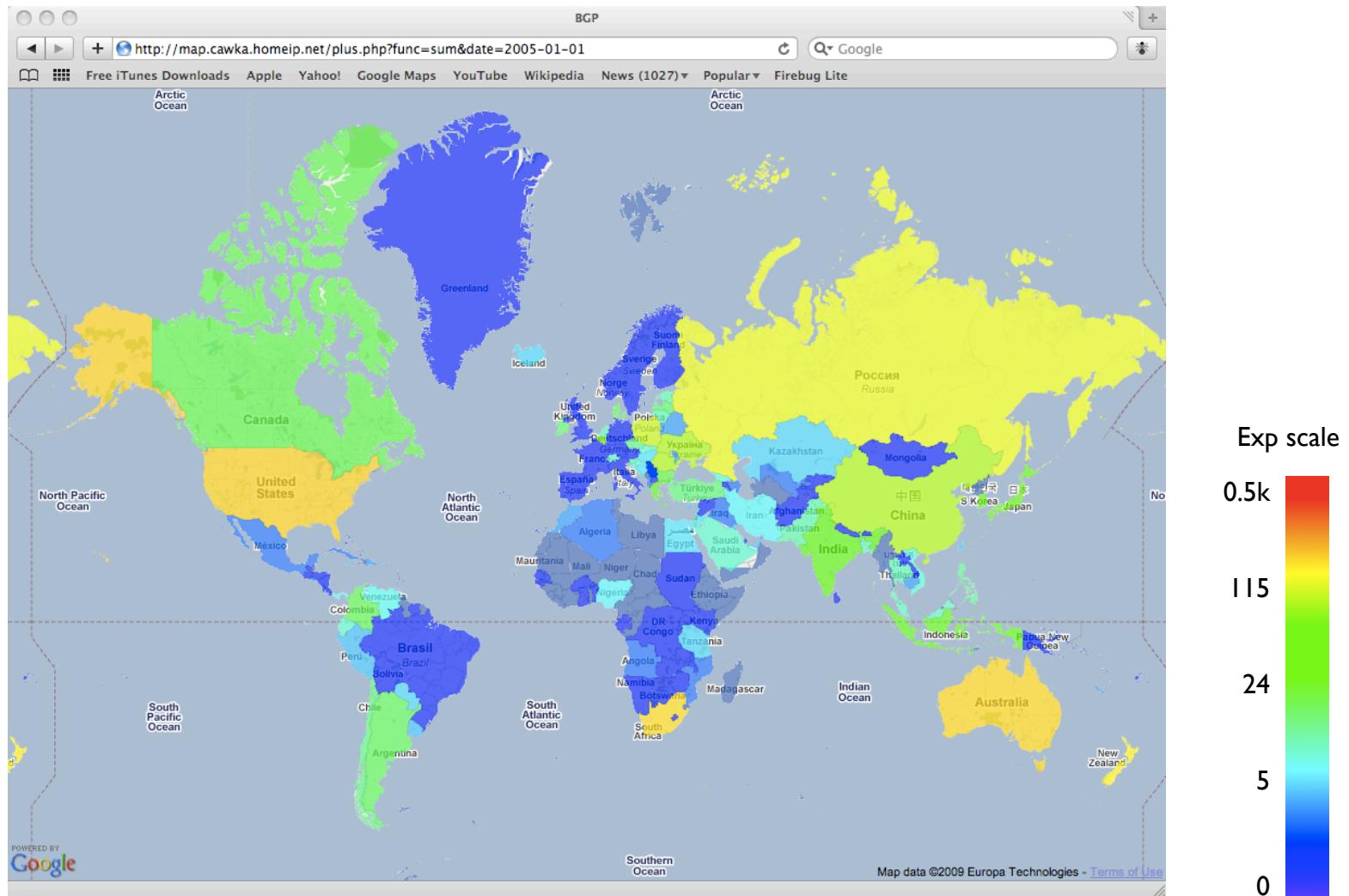
IP allocation changes geography **2003-2004**



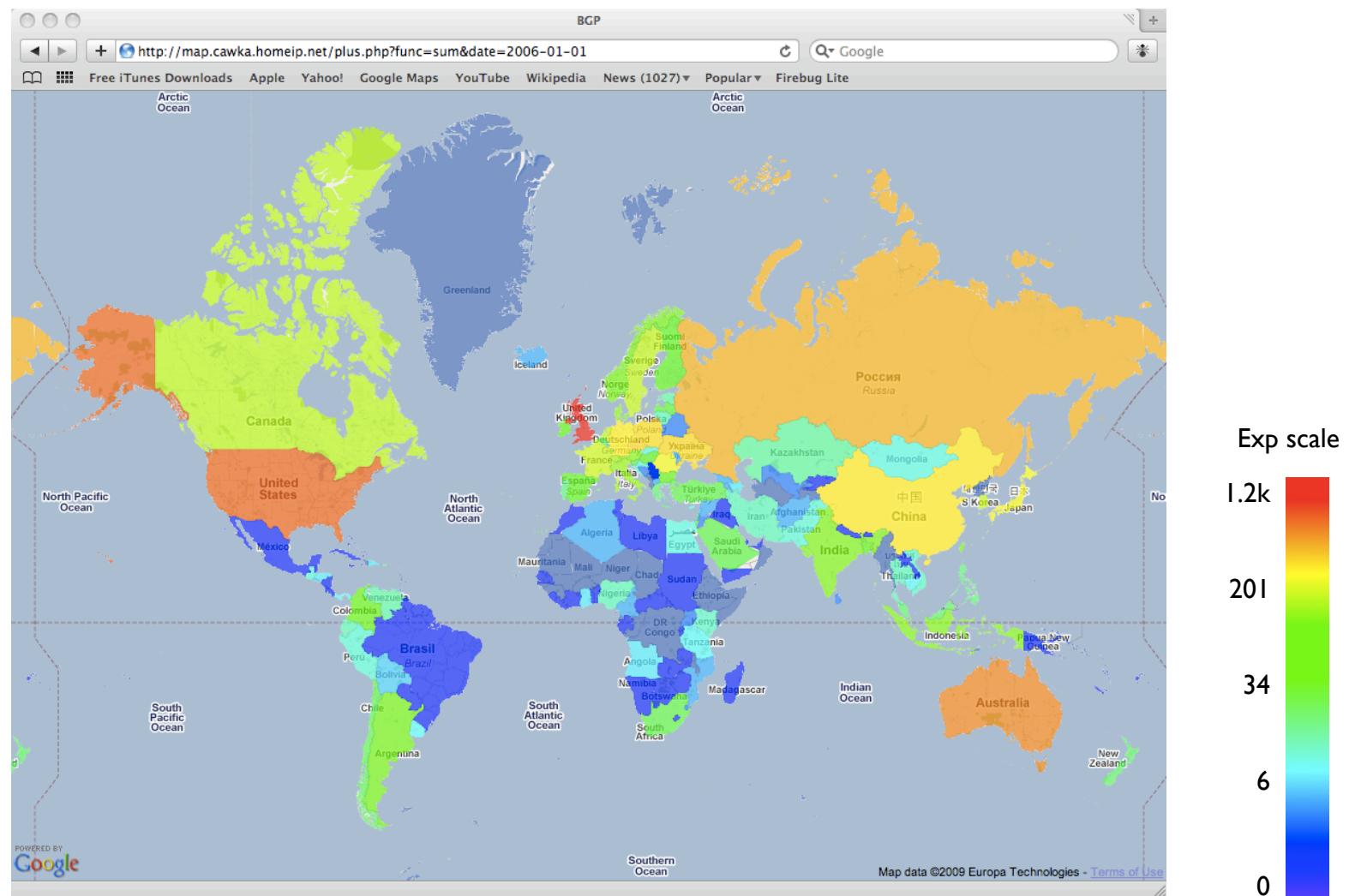
IP allocation changes geography **2004-2005**



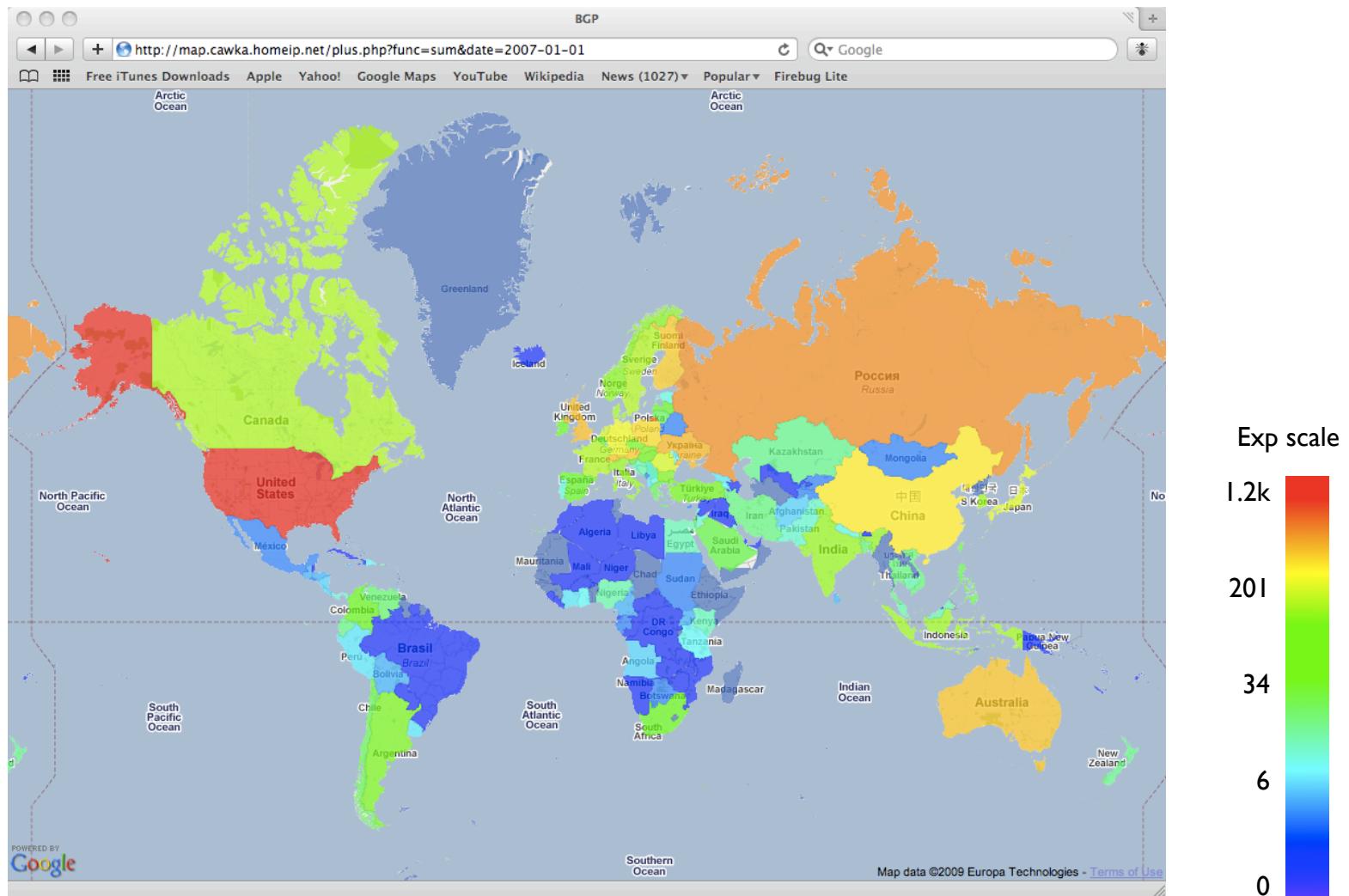
IP allocation changes geography 2005-2006



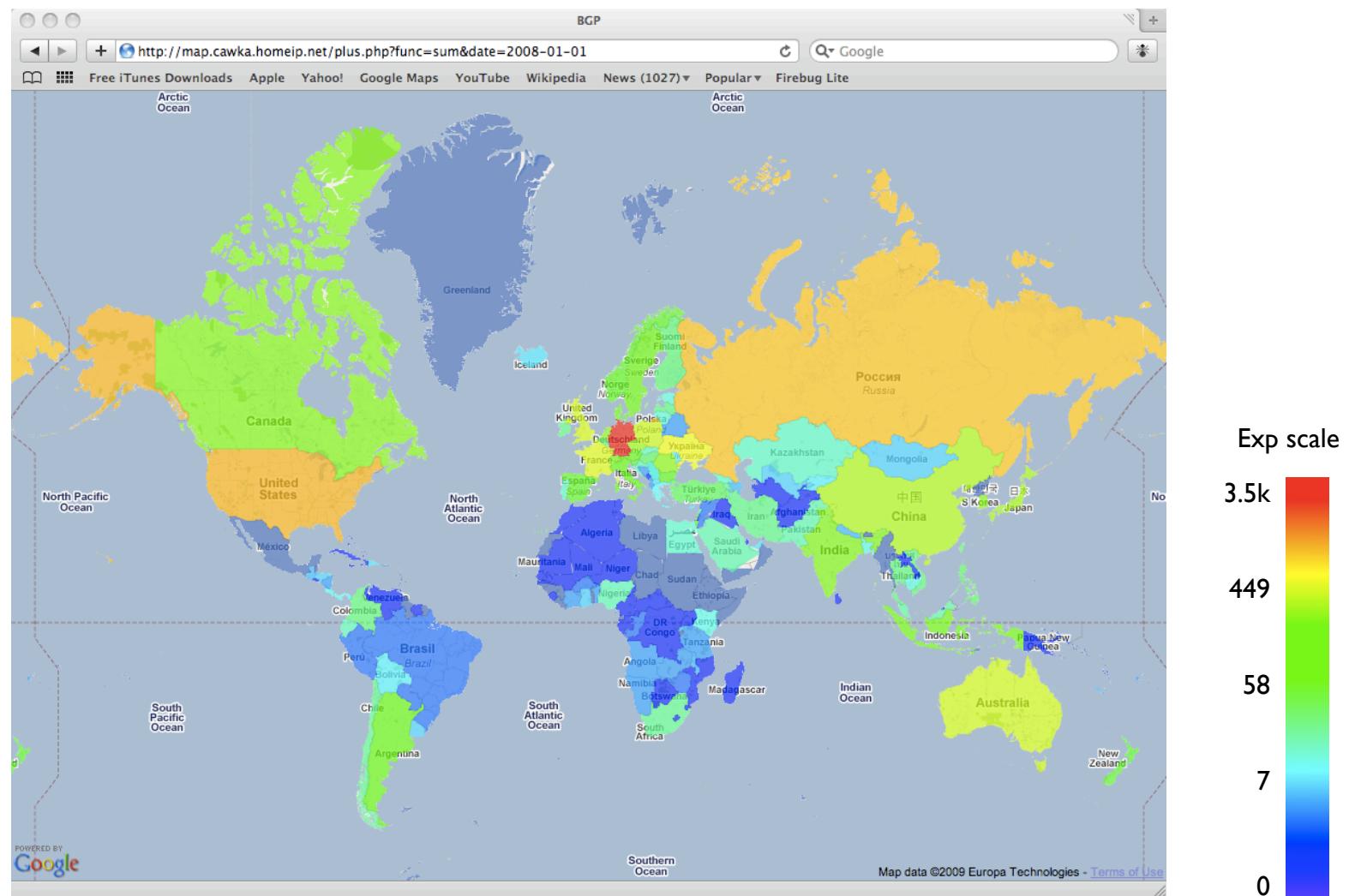
IP allocation changes geography **2006-2007**



IP allocation changes geography 2007-2008



IP allocation changes geography **2008-2009**



Conclusions

- ▶ BGP table has more than doubled in 6 years
- ▶ The BGP table growth outstrips IP allocation rate
- ▶ Every industrialized nation is participating in BGP table growth
- ▶ ISPs prefer to fragment large allocated blocks into smaller chunks, e.g., /24 prefixes account for more than 50% of routing table
- ▶ Demand for IP addresses outpaces the rate IPs are returned to RIRs
- ▶ Multihoming and traffic engineering techniques introduce redundancy in BGP table (58% in 2009)
- ▶ BGP table is highly dynamic (only 16% is static)

Thank you

- ▶ Open for questions
- ▶ Colored maps are available <http://maps.iu4.ru>