IPv6 Matrix Project

Tracking IPv6 connectivity Worldwide

http://www.ipv6matrix.org

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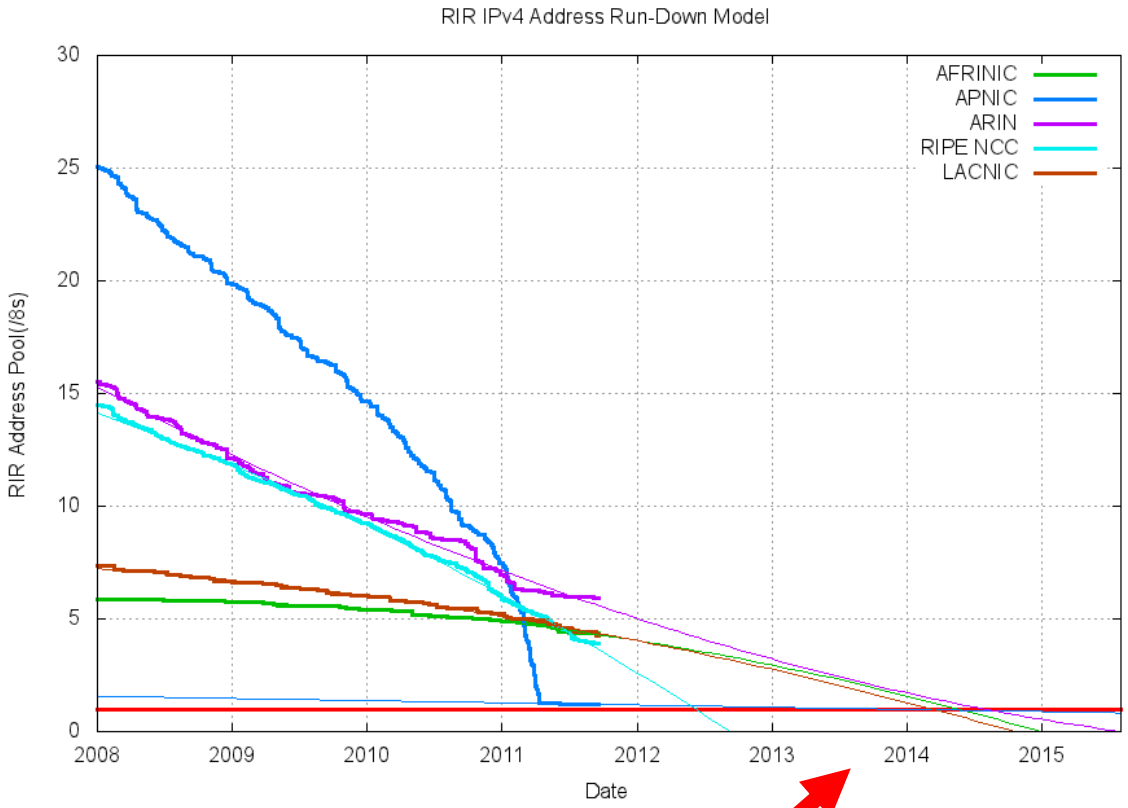
December 2012 Update 6 months after World IPv6 Launch

Internet Society England

We are running out of IP addresses



http://www.potaroo.net/tools/ipv4/index.html

When we reach this point, it will be too late since there will be no more "free" IPv4 addresses!

Real time data collected September 2011

Internet Society England

World IPv6 Launch

- In June 2012, major Internet service providers (ISPs), home networking equipment manufacturers, and web companies around the world came together to permanently enable IPv6 for their products and services.
- http://www.worldipv6launch.org
- HAS THIS “WORKED”?

IPv6 Matrix Project

- ISOC England was awarded a Community Grants Programme award in November 2009
- Design and implementation of an “IPv6 Crawler,” software on a computer that crawls through the DNS at regular intervals in order to detect and test:
  - IPv6 DNS servers
  - IPv6 compliant Web servers
  - IPv6 compliant SMTP mailers
  - IPv6 compliant NTP servers.

Project Rationale

- Today, more than 95% of Internet traffic is generated by a small number of data sources – i.e. the world's busiest Web Sites
- Without IPv6 accessible content, IPv6 has no chance of being used - ever.
- Take the 1 Million most popular Web site list from alexa.com as a starting point for the domains to be tested. Add more domains later.
- Test them for IPv6 connectivity
- This is equivalent to testing about 6.3 million hosts worldwide
- Use GeoIP database to estimate real host location

What are we tracking?

- Host IPv6 penetration
  - Using IPv4 Geo-location coordinates
  - Includes generic TLD (gTLDs, .com, .net, .org) and country code ccTLDs
- Two types of information:
  - Infrastructure: DNS + Web + E-mail + Time server (NTP)
    This tracks all of the infrastructure required to run IPv6 Web services
  - Web sites only (actual content)
    This tracks the Web services themselves. Usually this percentage is lower than the figure for the infrastructure

What are we archiving?

- Everything that we are tracking on the previous page, plus:
- Testing of connectivity to the above services in case IPv6 addresses are advertised but no service runs on them
- Tracing of route from London Docklands to each one of these hosts both using IPv4 and IPv6 – and archiving all of this information in text format
- A lot more data, accessible from the Web site archive
- In June 2012, the size of this database in text format is approx 140Gb and continually increasing (the testing software runs 24/7)

Results

December 2012

6 months after IPv6 Launch Day

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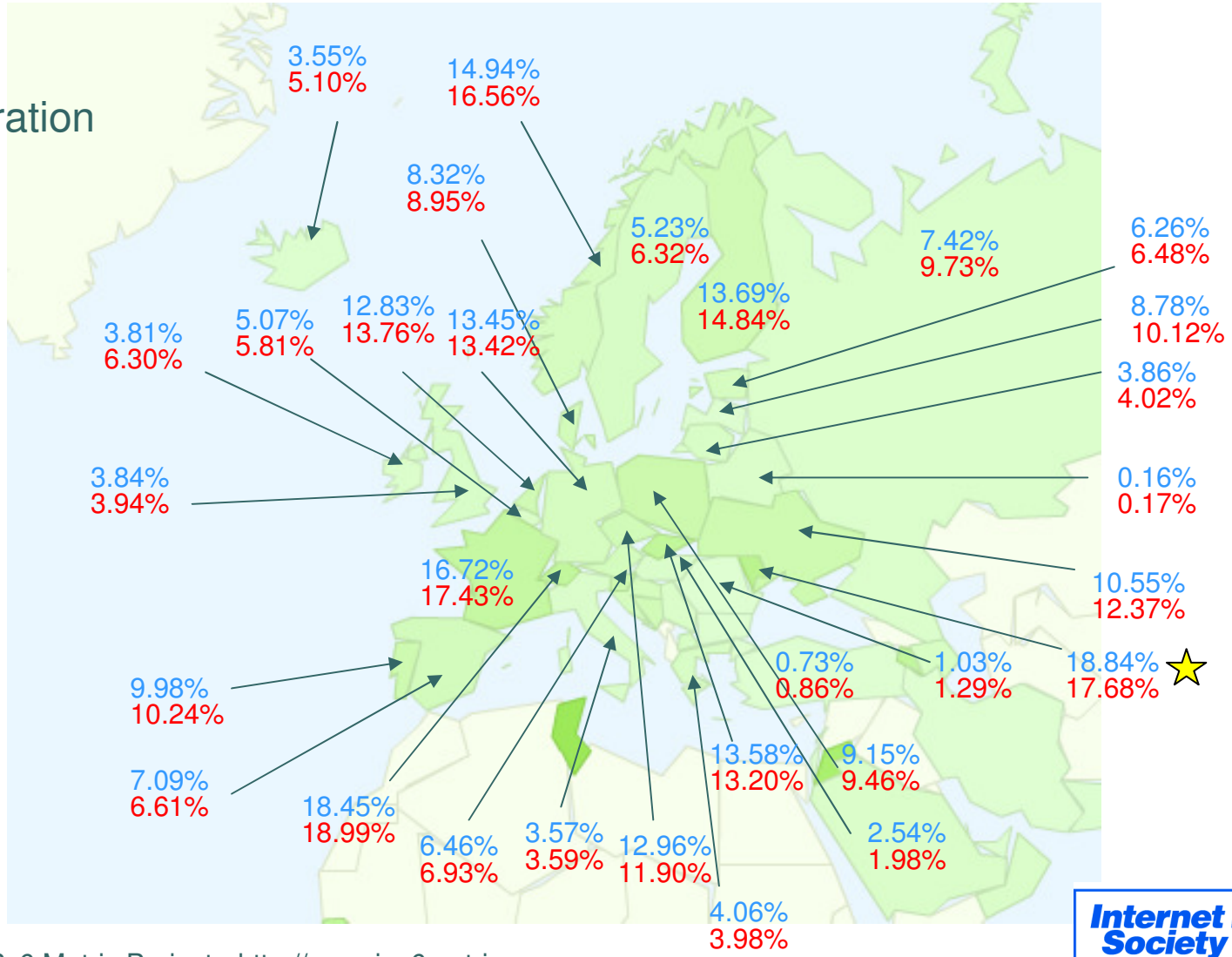
Europe Data snapshot

IPv6 Host Penetration

Infrastructure
- DNS
- Web
- E-mail
- NTP



★ Low Sample
Low accuracy

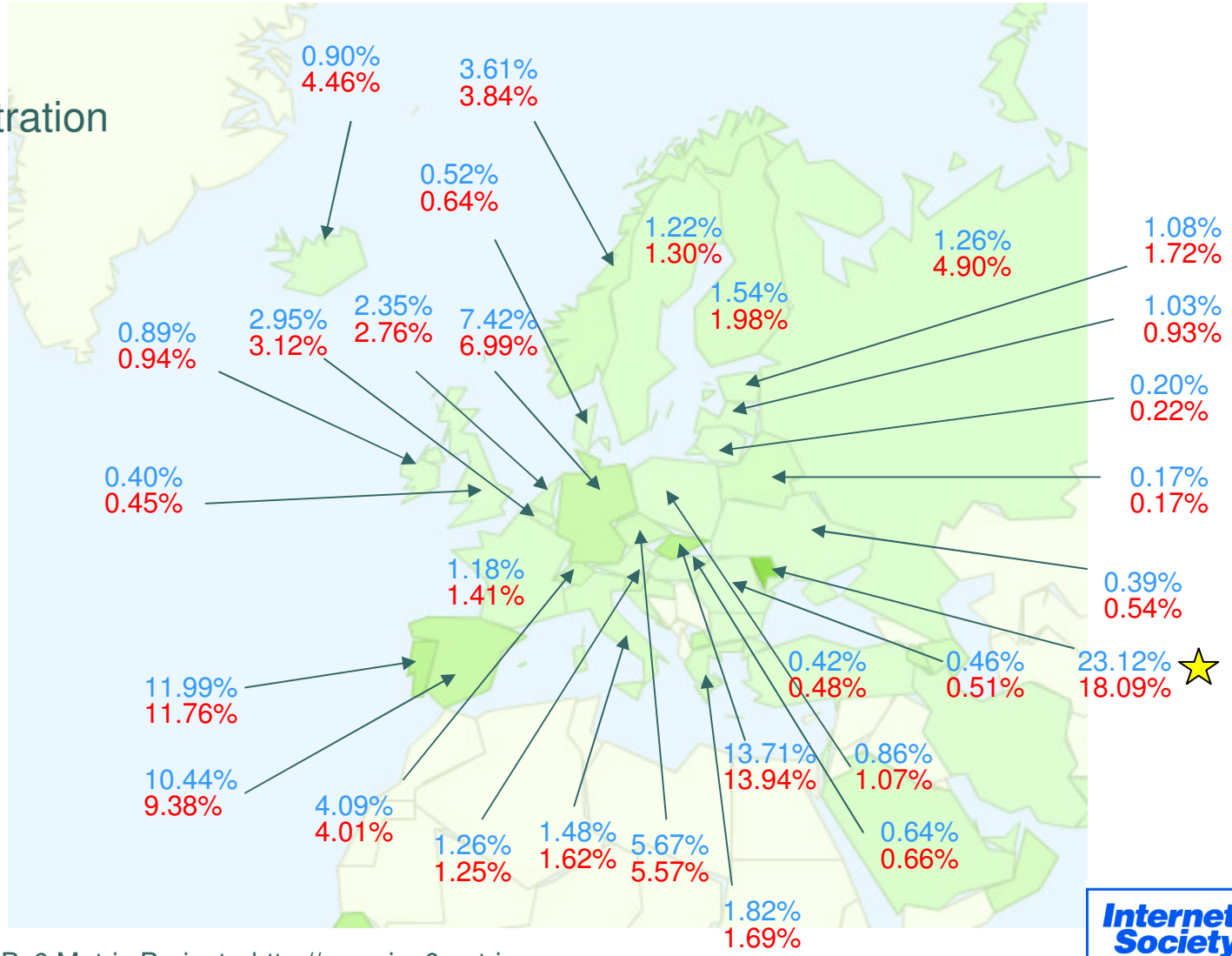
August 2012

December 2012

Europe Data snapshot

IPv6 Host Penetration

Web only



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August 2012

December 2012

IPv6 Host Penetration

Infrastructure
- DNS or
- Web or
- E-mail or
- NTP

(*) Low Sample
Low accuracy

Previous Order	Country	DNS+WEB+E-mail+NTP August 2012	December 2012	% change
1	Luxembourg	43.75%	59.14%	15.39%
4	Switzerland	18.45%	18.99%	0.54%
3	Moldova (*)	18.84%	17.68%	-1.16%
5	France	16.72%	17.43%	0.71%
6	Norway	14.94%	16.56%	1.62%
2	Liechtenstein	23.81%	15.38%	-8.43%
7	Finland	13.69%	14.84%	1.15%
10	Slovenia	13.01%	13.81%	0.80%
12	Netherlands	12.83%	13.76%	0.93%
9	Germany	13.45%	13.42%	-0.03%
8	Slovakia	13.58%	13.20%	-0.38%
13	Ukraine	10.55%	12.37%	1.82%
11	Czech Republic	12.96%	11.90%	-1.06%
14	Portugal	9.98%	10.24%	0.26%
16	Latvia	8.78%	10.12%	1.34%
18	Russia	7.42%	9.73%	2.31%
15	Poland	9.15%	9.46%	0.31%
17	Denmark	8.32%	8.95%	0.63%
21	Croatia	6.54%	7.40%	0.86%
20	Bosnia and Herzegovina (*)	6.76%	7.07%	0.31%
22	Austria	6.46%	6.93%	0.47%
19	Spain	7.09%	6.61%	-0.48%
23	Estonia	6.26%	6.48%	0.22%
24	Sweden	5.23%	6.32%	1.09%
30	Ireland	3.81%	6.30%	2.49%
36	Bulgaria	0.87%	5.86%	4.99%
25	Belgium	5.07%	5.81%	0.74%
32	Iceland	3.55%	5.10%	1.55%
26	Macedonia	4.43%	4.52%	0.09%
28	Lithuania	3.86%	4.02%	0.16%
27	Greece	4.06%	3.98%	-0.08%
29	United Kingdom	3.84%	3.94%	0.10%
31	Italy	3.57%	3.59%	0.02%
33	Serbia (*)	2.91%	3.07%	0.16%
34	Hungary	2.54%	1.98%	-0.56%
35	Romania	1.03%	1.29%	0.26%
37	Turkey	0.73%	0.86%	0.13%
38	Belarus	0.16%	0.17%	0.01%

IPv6 Host Penetration

Web only

(*) Low Sample
Low accuracy

Previous Order	Country	WEB August 2012	December 2012	% change
1	Moldova (*)	23.12%	18.09%	-5.03%
2	Slovakia	13.71%	13.94%	0.23%
3	Portugal	11.99%	11.76%	-0.23%
4	Spain	10.44%	9.38%	-1.06%
5	Germany	7.42%	6.99%	-0.43%
6	Slovenia	5.89%	5.86%	-0.03%
7	Czech Republic	5.67%	5.57%	-0.10%
19	Russia	1.26%	4.90%	3.64%
25	Iceland	0.90%	4.46%	3.56%
9	Macedonia	4.08%	4.12%	0.04%
8	Switzerland	4.09%	4.01%	-0.08%
10	Norway	3.61%	3.84%	0.23%
11	Luxembourg	3.35%	3.74%	0.39%
12	Belgium	2.95%	3.12%	0.17%
13	Netherlands	2.35%	2.76%	0.41%
14	Croatia	2.13%	2.56%	0.43%
17	Finland	1.54%	1.98%	0.44%
16	Serbia (*)	1.78%	1.78%	0.00%
23	Estonia	1.08%	1.72%	0.64%
15	Greece	1.82%	1.69%	-0.13%
18	Italy	1.48%	1.62%	0.14%
22	France	1.18%	1.41%	0.23%
21	Sweden	1.22%	1.30%	0.08%
20	Austria	1.26%	1.25%	-0.01%
27	Poland	0.86%	1.07%	0.21%
26	Ireland	0.89%	0.94%	0.05%
24	Latvia	1.03%	0.93%	-0.10%
28	Hungary	0.64%	0.66%	0.02%
29	Denmark	0.52%	0.64%	0.12%
34	Ukraine	0.39%	0.54%	0.15%
31	Romania	0.46%	0.51%	0.05%
32	Turkey	0.42%	0.48%	0.06%
30	Bulgaria	0.50%	0.45%	-0.05%
33	United Kingdom	0.40%	0.45%	0.05%
35	Lithuania	0.20%	0.22%	0.02%
36	Belarus	0.17%	0.17%	0.00%
37	Bosnia and Herzegovina (*)	0.00%	0.00%	0.00%
38	Liechtenstein	0.00%	0.00%	0.00%

Europe Trends

- Slow rise in infrastructure
  - Likely to be caused by a main hosting provider, installing dual-stack Name-servers
  - For example Bulgaria has seen significant growth
- Luxembourg with biggest growth in infrastructure
- Slovakia & Portugal still leading with dual-stack Web sites
- Russia catching up with big growth in Web sites
- Country with largest number of dual stack Web sites in Europe: Germany

Asia Data snapshot

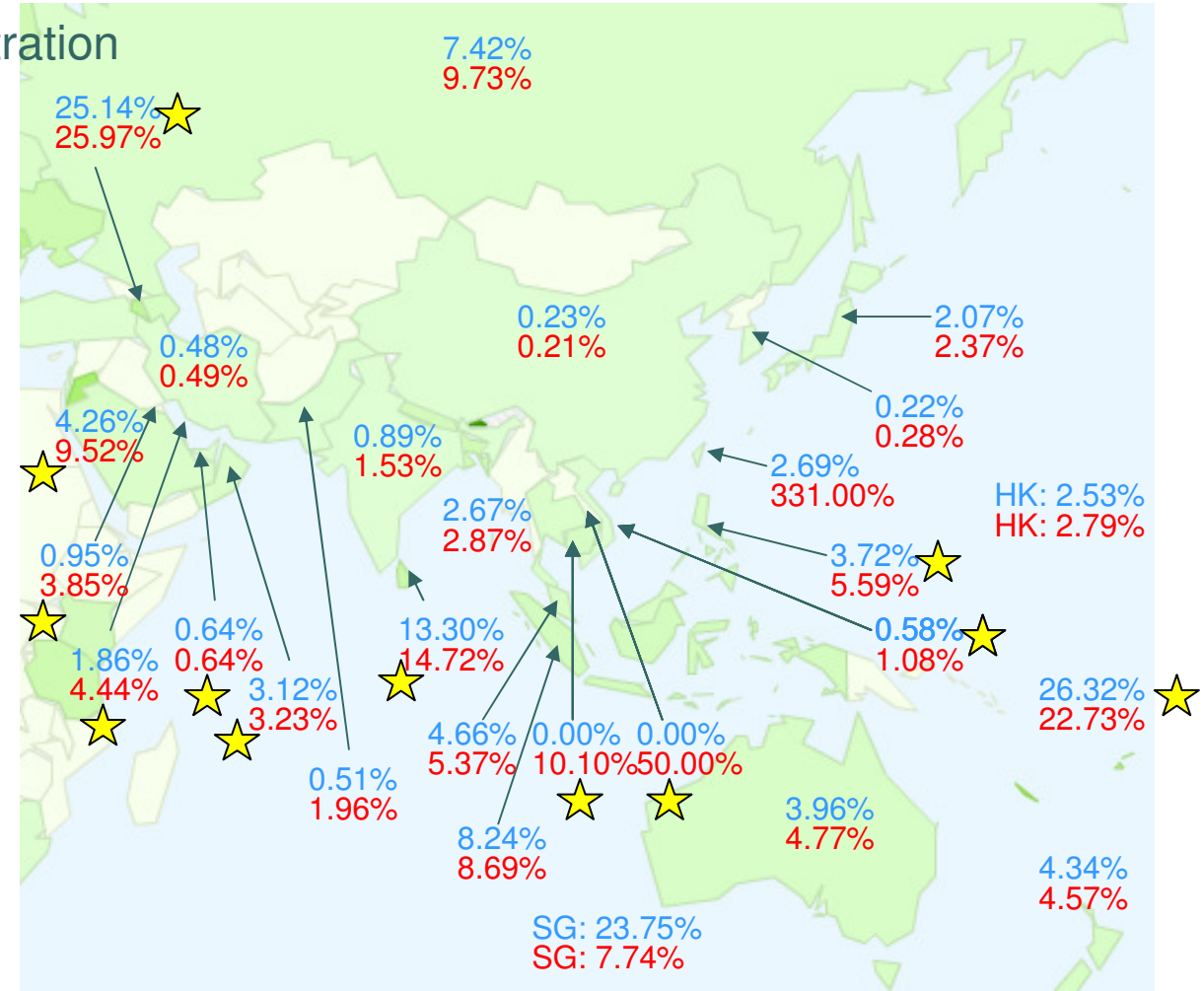
IPv6 Host Penetration

Infrastructure
- DNS or
- Web or
- E-mail or
- NTP

☆ Low Sample
Low accuracy

August 2012

December 2012



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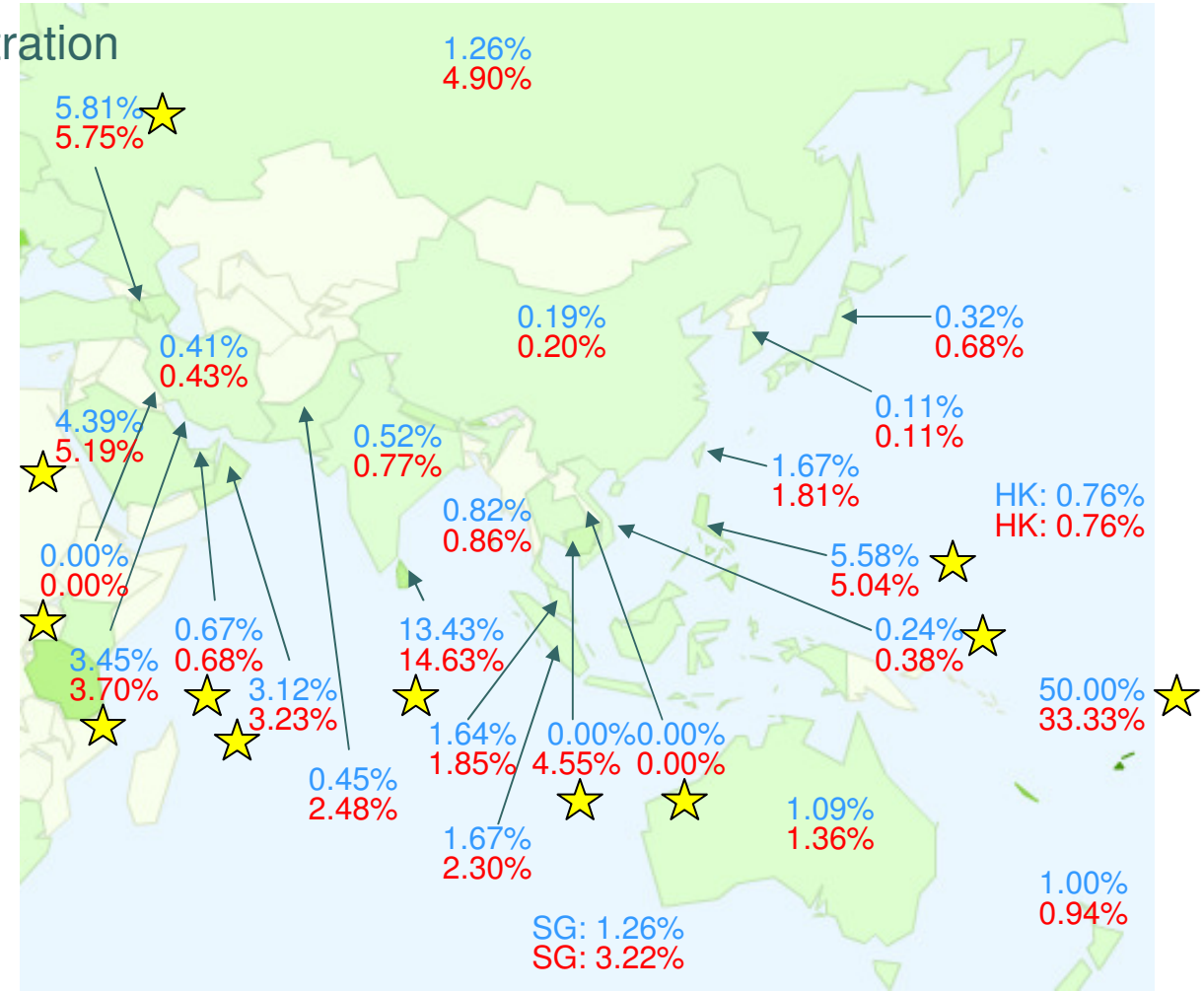
Asia Data snapshot

IPv6 Host Penetration

Web only



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Internet Society England

IPv6 Host Penetration

Infrastructure
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- NTP

(*) Low Sample
Low accuracy

Previous Order	Country	DNS+WEB+E-mail+NTP August 2012	December 2012	% change
27	Laos PDR	0.00%	50.00%	50.00%
2	Armenia (*)	25.14%	25.97%	0.83%
1	Fiji (*)	26.32%	22.73%	-3.59%
4	Sri Lanka (*)	13.30%	14.72%	1.42%
26	Cambodia	0.00%	10.10%	10.10%
6	Russia	7.42%	9.73%	2.31%
9	Saudi Arabia (*)	4.26%	9.52%	5.26%
5	Indonesia	8.24%	8.69%	0.45%
3	Singapore	23.75%	7.74%	-16.01%
11	Philippines (*)	3.72%	5.59%	1.87%
7	Malaysia	4.66%	5.37%	0.71%
10	Australia	3.96%	4.77%	0.81%
8	New Zealand	4.34%	4.57%	0.23%
17	Qatar (*)	1.86%	4.44%	2.58%
18	Kuwait (*)	0.95%	3.85%	2.90%
13	Taiwan	2.69%	3.31%	0.62%
12	Oman (*)	3.12%	3.23%	0.11%
14	Thailand	2.67%	2.87%	0.20%
15	Hong Kong	2.53%	2.79%	0.26%
16	Japan	2.07%	2.37%	0.30%
22	Pakistan	0.51%	1.96%	1.45%
19	India	0.89%	1.53%	0.64%
21	Vietnam (*)	0.58%	1.08%	0.50%
20	United Arab Emirates (*)	0.64%	0.64%	0.00%
23	Iran	0.48%	0.49%	0.01%
25	South Korea	0.22%	0.28%	0.06%
24	China	0.23%	0.21%	-0.02%

IPv6 Host Penetration

Web only

(*) Low Sample
Low accuracy

Previous Order	Country	WEB August 2012	December 2012	% change
1	Fiji (*)	50.00%	33.33%	-16.67%
2	Sri Lanka (*)	13.43%	14.63%	1.20%
3	Armenia (*)	5.81%	5.75%	-0.06%
5	Saudi Arabia (*)	4.39%	5.19%	0.80%
4	Philippines (*)	5.58%	5.04%	-0.54%
11	Russia	1.26%	4.90%	3.64%
26	Cambodia	0.00%	4.55%	4.55%
6	Qatar (*)	3.45%	3.70%	0.25%
7	Oman (*)	3.12%	3.23%	0.11%
12	Singapore	1.26%	3.22%	1.96%
19	Pakistan	0.45%	2.48%	2.03%
9	Indonesia	1.67%	2.30%	0.63%
10	Malaysia	1.64%	1.85%	0.21%
8	Taiwan	1.67%	1.81%	0.14%
13	Australia	1.09%	1.36%	0.27%
14	New Zealand	1.00%	0.94%	-0.06%
15	Thailand	0.82%	0.86%	0.04%
18	India	0.52%	0.77%	0.25%
16	Hong Kong	0.76%	0.76%	0.00%
17	United Arab Emirates (*)	0.67%	0.68%	0.01%
21	Japan	0.32%	0.68%	0.36%
20	Iran	0.41%	0.43%	0.02%
22	Vietnam (*)	0.24%	0.38%	0.14%
23	China	0.19%	0.20%	0.01%
24	South Korea	0.11%	0.11%	0.00%
25	Kuwait (*)	0.00%	0.00%	0.00%
27	Laos PDR	0.00%	0.00%	0.00%

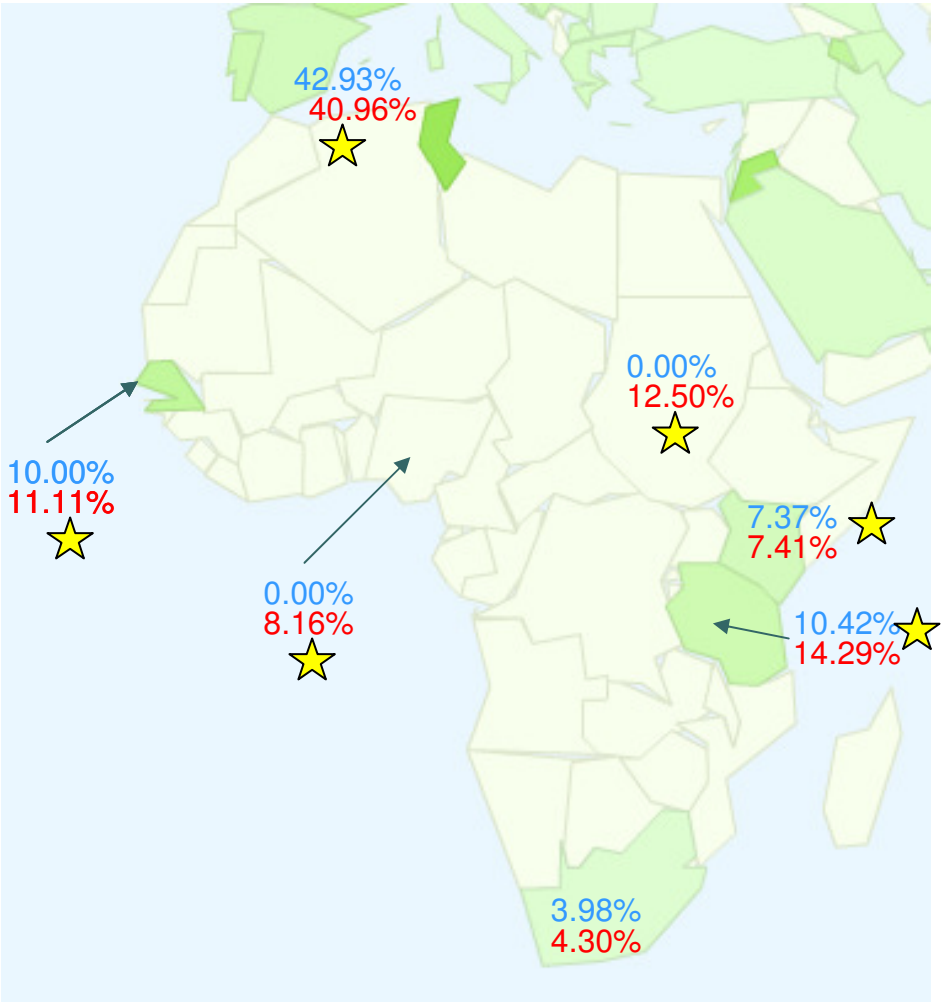
Asia Trends

- Drop in Singapore results – caused by network restructuring or blacklisting?
- Russia growth continues in infrastructure
- As expected, Russia growth now in Web content too
- China results abnormally very low – content not dual stacked or IPv6 behind firewall?
- India also low both in infrastructure and most popular Web sites with dual stack
- Less reliability of results due to smaller sample size in many countries of the region

Africa Data snapshot

IPv6 Host Penetration

Infrastructure
- DNS or
- Web or
- E-mail or
- NTP



Low Sample
Low accuracy

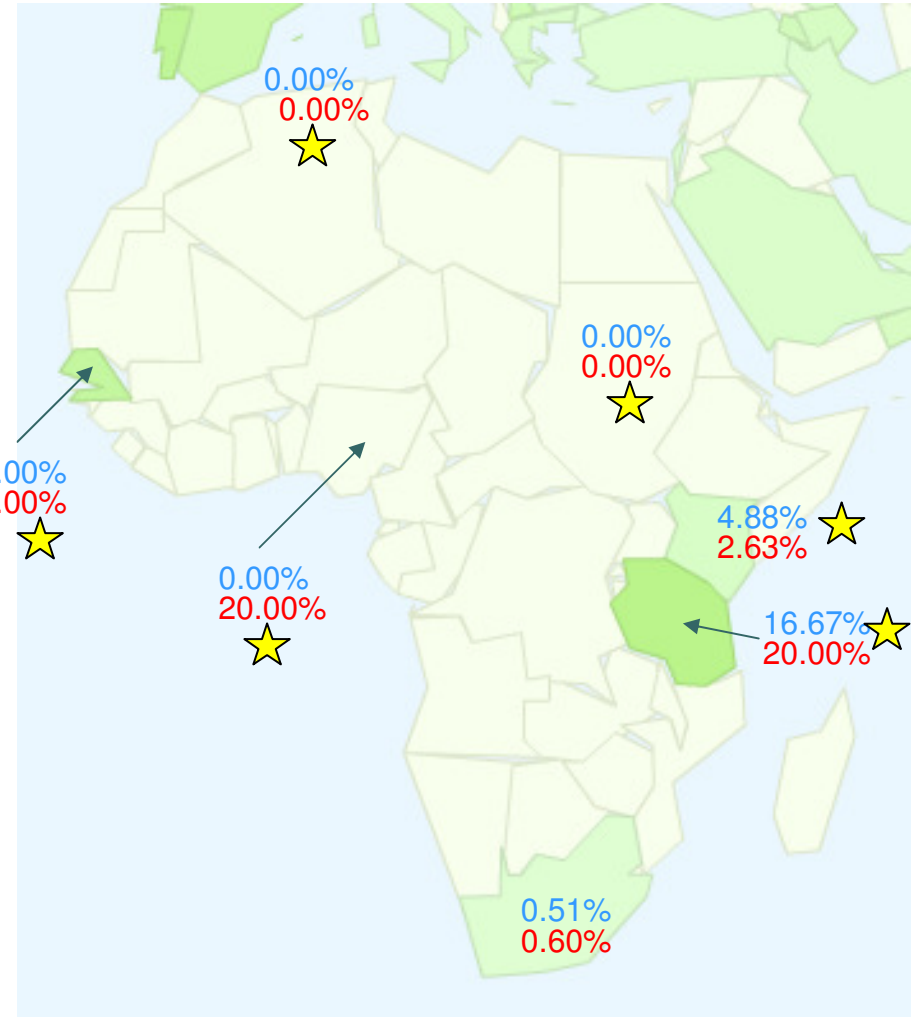
August 2012

December 2012

Africa Data snapshot

IPv6 Host Penetration

Web only



Low Sample
Low accuracy

August 2012

December 2012

IPv6 Host Penetration

Infrastructure
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(*) Low Sample
Low accuracy

Country	DNS+WEB+E-mail+NTP		% change
	August 2012	December 2012	
Tunisia (*)	42.93%	40.96%	-1.97%
Tanzania (*)	10.42%	14.29%	3.87%
Sudan (*)	0.00%	12.50%	12.50%
Senegal (*)	10.00%	11.11%	1.11%
Nigeria (*)	0.00%	8.16%	8.16%
Kenya (*)	7.37%	7.41%	0.04%
South Africa	3.98%	4.30%	0.32%
Algeria	0.00%	1.57%	1.57%

The small number of hosts tested make the results for most of Africa appear higher than they really are

IPv6 Host Penetration

Web only

Country	WEB		% change
	August 2012	December 2012	
Tanzania (*)	16.67%	20.00%	3.33%
Nigeria (*)	0.00%	20.00%	20.00%
Kenya (*)	4.88%	2.63%	-2.25%
South Africa	0.51%	0.60%	0.09%
Algeria	0.00%	0.00%	0.00%
Senegal (*)	0.00%	0.00%	0.00%
Tunisia (*)	0.00%	0.00%	0.00%
Sudan (*)	0.00%	0.00%	0.00%

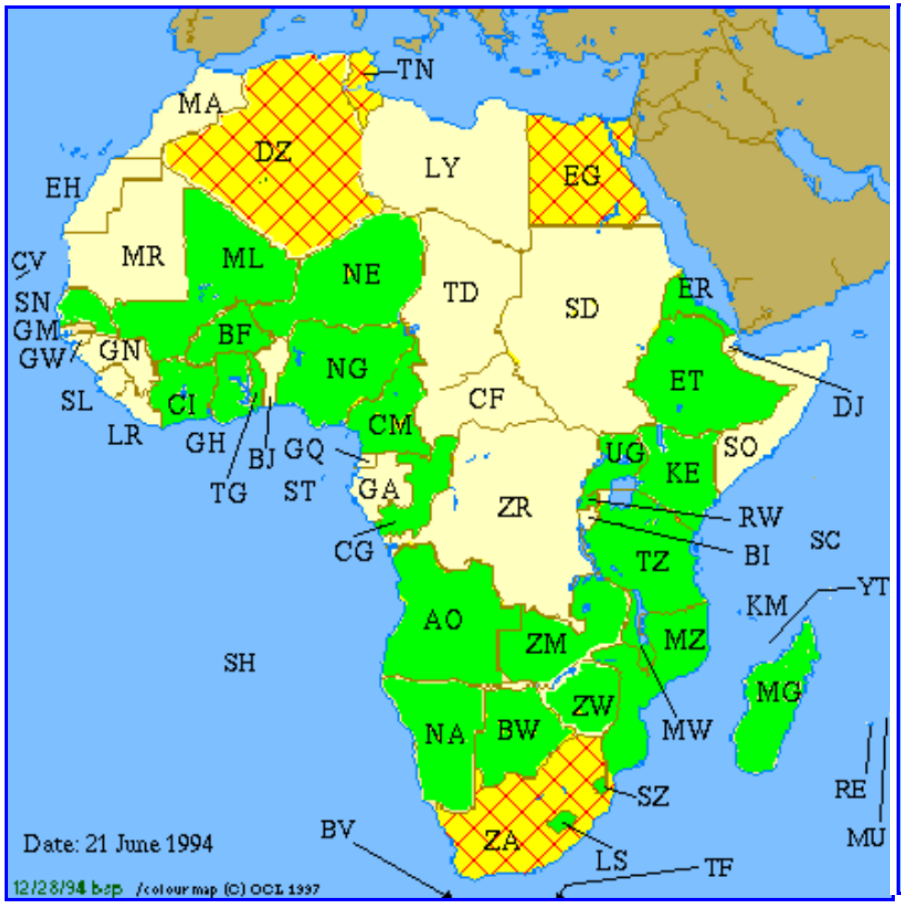
(*) Low Sample
Low accuracy

The small number of hosts tested make the results for most of Africa appear higher than they really are

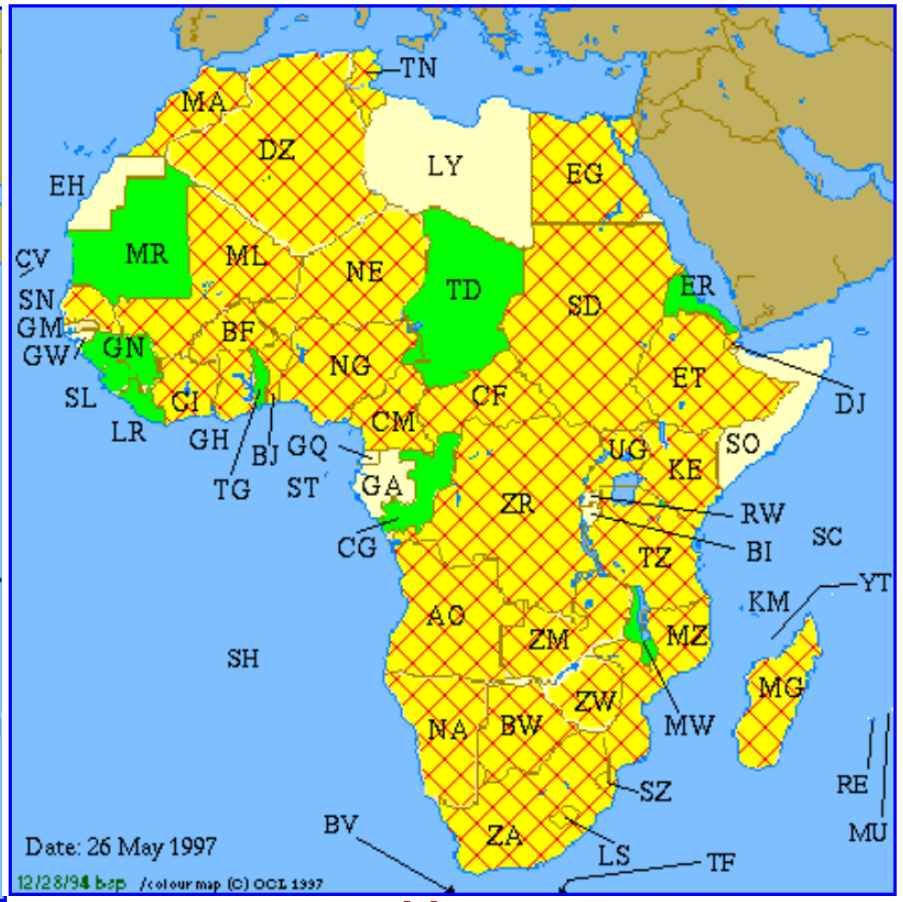
Africa Trends

- Many countries now have IPv6 capability, some through tunnels
- Dual Stack Islands starting to appear
  - Sudan and Nigeria, for example
- Can be compared with the growth of Internet connectivity in the nineties

Compare Historical data on African Internet Connectivity



June 1994



May 1997

Source: Internetology - http://www.nsrc.org/codes/bymap/ntlgy/ntlgy.htm

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North/South America

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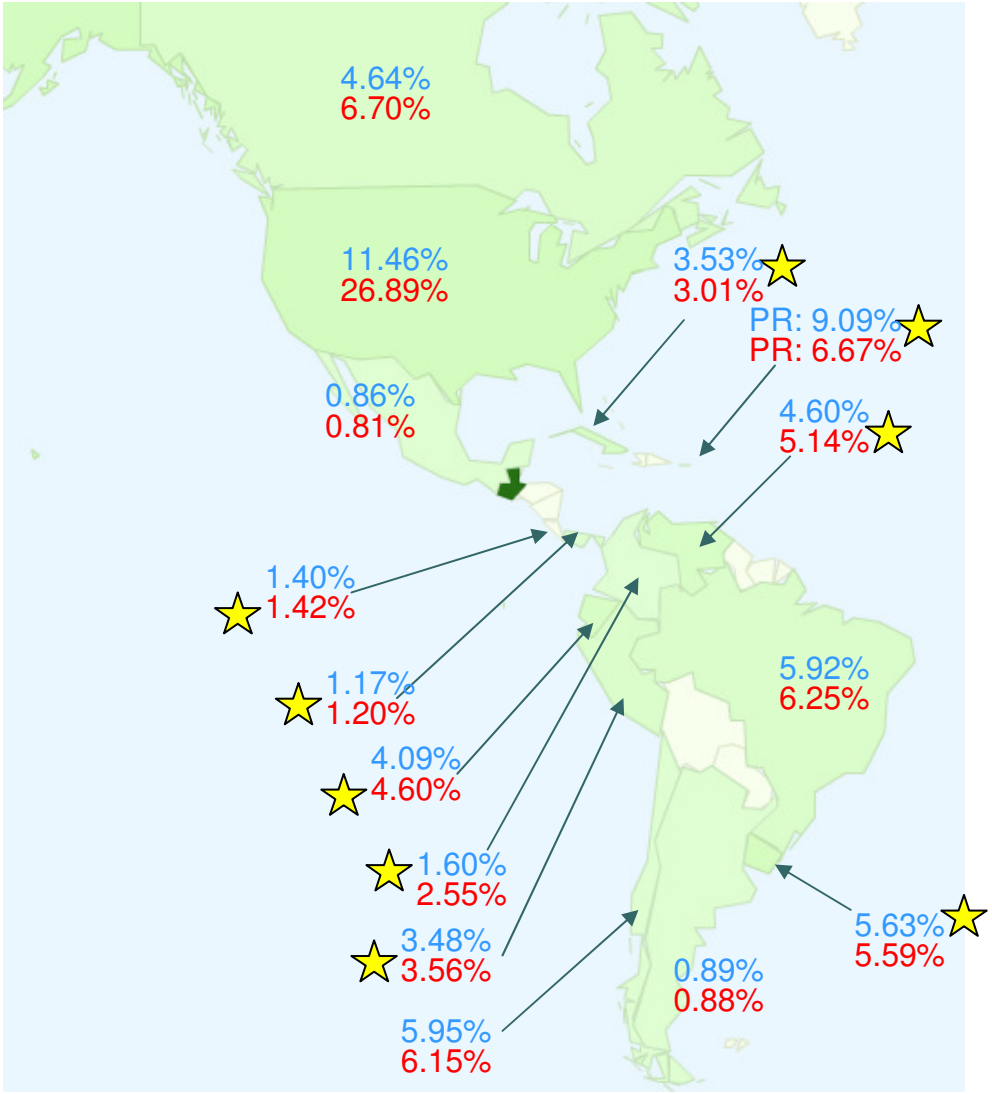

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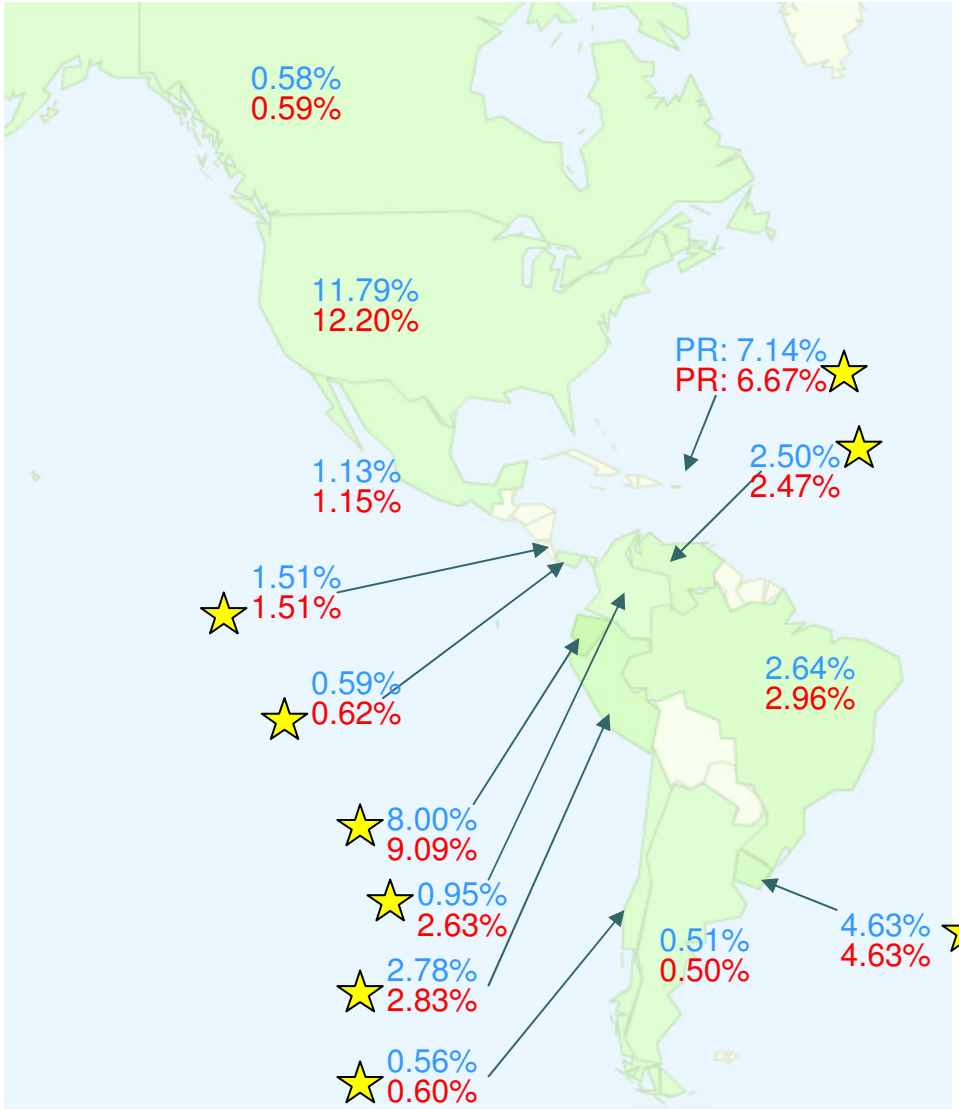
December 2012

North/South America

IPv6 Host Penetration

Web only



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IPv6 Host Penetration

Infrastructure
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Previous Order	Country	DNS+WEB+E-mail+NTP August 2012	December 2012	% change
1	United States	11.46%	26.89%	15.43%
6	Canada	4.64%	6.70%	2.06%
2	Puerto Rico (*)	9.09%	6.67%	-2.42%
4	Brasil	5.92%	6.25%	0.33%
3	Chile	5.95%	6.15%	0.20%
5	Uruguay (*)	5.63%	5.59%	-0.04%
7	Venezuela (*)	4.60%	5.14%	0.54%
8	Ecuador (*)	4.09%	4.60%	0.51%
10	Peru (*)	3.48%	3.56%	0.08%
9	Cuba (*)	3.53%	3.01%	-0.52%
11	Colombia (*)	1.60%	2.55%	0.95%
12	Costa Rica	1.40%	1.42%	0.02%
13	Panama (*)	1.17%	1.20%	0.03%
14	Argentina	0.89%	0.88%	-0.01%
15	Mexico	0.86%	0.81%	-0.05%
16	Guatemala (*)	0.00%	0.00%	0.00%

(*) Low Sample
Low accuracy

For (*) the small number of hosts tested make the results in many countries appear higher than they really are

IPv6 Host Penetration

Web only

Previous Order	Country	WEB August 2012	December 2012	% change
1	United States	11.79%	12.20%	0.41%
2	Ecuador (*)	8.00%	9.09%	1.09%
3	Puerto Rico (*)	7.14%	6.67%	-0.47%
4	Uruguay (*)	4.63%	4.63%	0.00%
6	Brasil	2.64%	2.96%	0.32%
5	Peru (*)	2.78%	2.83%	0.05%
10	Colombia (*)	0.95%	2.63%	1.68%
7	Venezuela (*)	2.50%	2.47%	-0.03%
8	Costa Rica	1.51%	1.51%	0.00%
9	Mexico	1.13%	1.15%	0.02%
11	Panama (*)	0.59%	0.62%	0.03%
13	Chile	0.56%	0.60%	0.04%
12	Canada	0.58%	0.59%	0.01%
14	Argentina	0.51%	0.50%	-0.01%
15	Guatemala (*)	0.00%	0.00%	0.00%
16	Cuba (*)	0.00%	0.00%	0.00%

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Low accuracy

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Internet Society England

America Trends

- USA now leading the region both in infrastructure and in dual stack Web sites
  - Largest number of IPv6 hosts: 103577
- Brazil leading in Latin America with 204 Dual Stack Web Site hosts
- Elsewhere, data based on low number of Web sites, needs to be taken in moderation (the restricted number of hosting providers can make figures jump several percentage points)

Worldwide Trends

- We are seeing a slow but steady growth in dual stack IPv4-IPv6 implementation
- A decrease in percentage in some countries, points to unstable peering agreements (the IPv6 network is less closely meshed than the IPv4 network)
- The USA have overtaken Germany in the number of Dual Stack Web sites among world's most popular Web sites: 103577 hosts vs. 15652 hosts out of a sample size of 849 000 vs 224 074 hosts tested
- Bearing in mind the Asia Pacific Regional Internet Registry has run out of IPv4 addresses, it is alarming to see so few Web sites up and running IPv6 in that region, especially in countries where Internet growth is high, such as in India.

Problems / Possible Errors

- Lots of errors in the DNS – commas, no A, no AAAA record, looping MX, etc.
- Firewalls and security software:
  - Blocking of network segments
  - detecting denial of service attack (DoS) by error:
    - Unusual UDP traffic. Trace-path / ping, SMTP, HTTP, Secure HTTP, NTP port testing.
- Internet snapshot from one location only
- Less accurate results with small input data size (small number of domains tested)
- Disputed accuracy of Geographical IP database

Future work / funding required

- Add more domains to be tested
- Add more features to be tested
- Current front end Web Pages are only an example of possible analysis
  - Develop new data visualisation
  - Perform further analysis
  - Perform historical/time analysis from archives
  - Develop an engine to write automated reports
- Duplicate Crawler to other regions

Thank you

Contact: ISOC England – contact@isoc-e.org