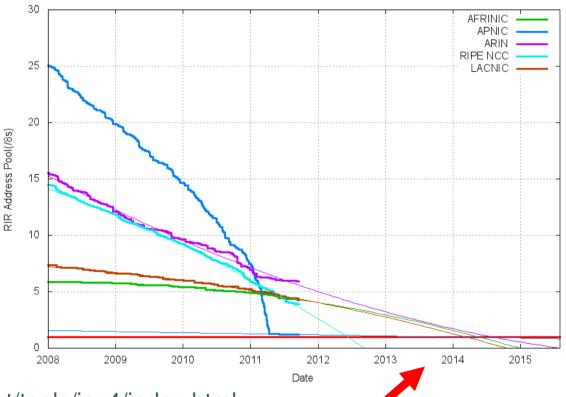# IPv6 Matrix Project

Tracking IPv6 connectivity Worldwide

http://www.ipv6matrix.org

Dr. Olivier MJ Crépin-Leblond – ocl@gih.com
August 2012 Update / 1 month after World IPv6 Launch

Internet Society
England

We are running out of IP addresses

RIR IPv4 Address Run-Down Model

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

IPv6 Matrix Project - http://www.ipv6matrix.org

Internet Society England

World IPv6 Launch

- Major Internet service providers (ISPs), home networking equipment manufacturers, and web companies around the world are coming 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.

Internet Society **England**

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

IPv6 Matrix Project - http://www.ipv6matrix.org

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England

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

IPv6 Matrix Project - http://www.ipv6matrix.org

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Society
England

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 August, the size of this database in text format is approx 160Gb and continually increasing (the testing software runs 24/7)
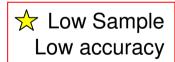
IPv6 Matrix Project - http://www.ipv6matrix.org

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Results

August 2012

1 month after IPv6 Launch Day

IPv6 Matrix Project - http://www.ipv6matrix.org

Europe Data snapshot

IPv6 Host Penetration

Infrastructure
- DNS
- Web
- E-mail
- NTP

⭐ Low Sample
Low accuracy

4 June 2012

August 2012

2.77%
3.55%

5.58%
14.94%

8.24%
8.32%

5.06%
5.23%

6.96%
7.42%

6.92%
6.26%

13.52%
13.69%

7.44%
8.78%

2.66%
3.81%

4.96%
5.07%

11.87%
12.83%

7.07%
13.45%

3.88%
3.86%

3.70%
3.84%

0.16%
0.16%

15.81%
16.72%

10.53%
10.55%

9.98%
9.98%

0.65%
0.73%

0.93%
1.03%

18.36%
18.84% ⭐

6.92%
7.09%

12.19%
13.58%

8.87%
9.15%

16.73%
18.45%

6.50%
6.46%

3.51%
3.57%

12.20%
12.96%

2.71%
2.54%

4.04%
4.06%

IPv6 Matrix Project - http://www.ipv6matrix.org
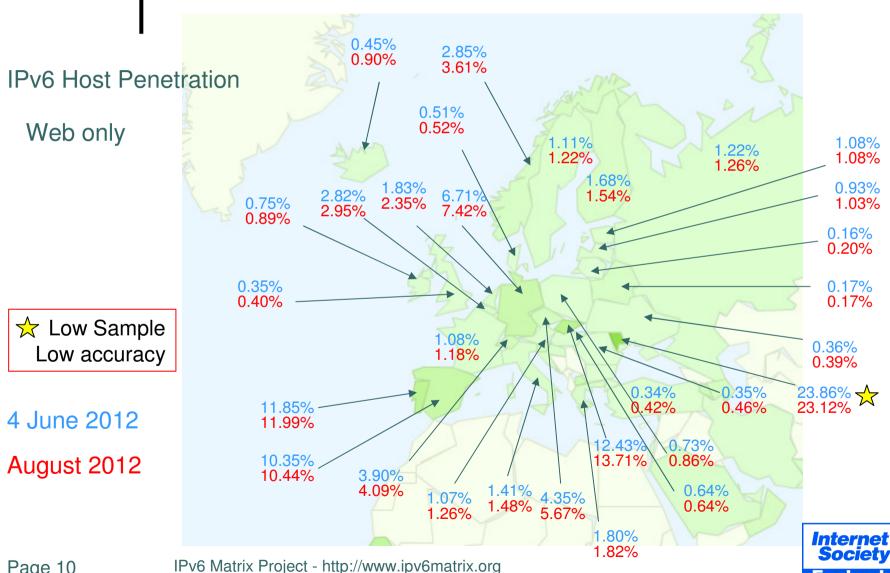
Internet Society **England**

Europe Data snapshot

IPv6 Host Penetration

Web only

⭐ Low Sample
Low accuracy

4 June 2012

August 2012

0.45%
0.90%

2.85%
3.61%

0.51%
0.52%

1.11%
1.22%

1.22%
1.26%

1.08%
1.08%

1.68%
1.54%

0.93%
1.03%

0.75%
0.89%

2.82%
2.95%

1.83%
2.35%

6.71%
7.42%

0.16%
0.20%

0.35%
0.40%

0.17%
0.17%

1.08%
1.18%

0.36%
0.39%

11.85%
11.99%

0.34%
0.42%

0.35%
0.46%

23.86% ⭐
23.12%

10.35%
10.44%

12.43%
13.71%

0.73%
0.86%

3.90%
4.09%

1.07%
1.26%

1.41%
1.48%

4.35%
5.67%

0.64%
0.64%

1.80%
1.82%

IPv6 Matrix Project - http://www.ipv6matrix.org

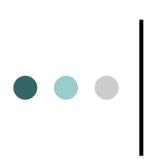Internet Society England

IPv6 Host Penetration

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

(*) Low Sample
Low accuracy

Previous Order	Country	DNS+WEB+E-mail+NTP 4 June 2012	August 2012	% change
25	Luxembourg	4.80%	43.75%	38.95%
1	Liechtenstein	22.00%	23.81%	1.81%
2	Moldova (*)	18.36%	18.84%	0.48%
3	Switzerland	16.73%	18.45%	1.72%
4	France	15.81%	16.72%	0.91%
22	Norway	5.58%	14.94%	9.36%
6	Finland	13.52%	13.69%	0.17%
8	Slovakia	12.19%	13.58%	1.39%
15	Germany	7.07%	13.45%	6.38%
5	Slovenia	13.69%	13.01%	-0.68%
7	Czech Republic	12.20%	12.96%	0.76%
9	Netherlands	11.87%	12.83%	0.96%
10	Ukraine	10.53%	10.55%	0.02%
11	Portugal	9.98%	9.98%	0.00%
12	Poland	8.87%	9.15%	0.28%
14	Latvia	7.44%	8.78%	1.34%
13	Denmark	8.24%	8.32%	0.08%
16	Russia	6.96%	7.42%	0.46%
17	Spain	6.92%	7.09%	0.17%
19	Bosnia and Herzegovina (*)	6.54%	6.76%	0.22%
21	Croatia	6.28%	6.54%	0.26%
20	Austria	6.50%	6.46%	-0.04%
18	Estonia	6.92%	6.26%	-0.66%
23	Sweden	5.06%	5.23%	0.17%
24	Belgium	4.96%	5.07%	0.11%
30	Macedonia	3.33%	4.43%	1.10%
26	Greece	4.04%	4.06%	0.02%
27	Lithuania	3.88%	3.86%	-0.02%
28	United Kingdom	3.70%	3.84%	0.14%
33	Ireland	2.66%	3.81%	1.15%
29	Italy	3.51%	3.57%	0.06%
31	Iceland	2.77%	3.55%	0.78%
34	Serbia (*)	2.53%	2.91%	0.38%
32	Hungary	2.71%	2.54%	-0.17%
35	Romania	0.93%	1.03%	0.10%
36	Bulgaria	0.81%	0.87%	0.06%
37	Turkey	0.65%	0.73%	0.08%

IPv6 Matrix Project - http://www.ipv6matrix.org

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IPv6 Host Penetration

Web only

(*) Low Sample
Low accuracy

Previous Order	Country	WEB 4 June 2012	August 2012	% change
1	Moldova (*)	23.86%	23.12%	-0.74%
2	Slovakia	12.43%	13.71%	1.28%
3	Portugal	11.85%	11.99%	0.14%
4	Spain	10.35%	10.44%	0.09%
5	Germany	6.71%	7.42%	0.71%
6	Slovenia	5.53%	5.89%	0.36%
7	Czech Republic	4.35%	5.67%	1.32%
8	Switzerland	3.90%	4.09%	0.19%
9	Macedonia	3.12%	4.08%	0.96%
11	Norway	2.85%	3.61%	0.76%
10	Luxembourg	3.35%	3.35%	0.00%
12	Belgium	2.82%	2.95%	0.13%
13	Netherlands	1.83%	2.35%	0.52%
16	Croatia	1.45%	2.13%	0.68%
14	Greece	1.80%	1.82%	0.02%
27	Serbia (*)	0.59%	1.78%	1.19%
15	Finland	1.68%	1.54%	-0.14%
17	Italy	1.41%	1.48%	0.07%
18	Russia	1.22%	1.26%	0.04%
22	Austria	1.07%	1.26%	0.19%
19	Sweden	1.11%	1.22%	0.11%
21	France	1.08%	1.18%	0.10%
20	Estonia	1.08%	1.08%	0.00%
23	Latvia	0.93%	1.03%	0.10%
29	Iceland	0.45%	0.90%	0.45%
24	Ireland	0.75%	0.89%	0.14%
25	Poland	0.73%	0.86%	0.13%
26	Hungary	0.64%	0.64%	0.00%
28	Denmark	0.51%	0.52%	0.01%
30	Bulgaria	0.45%	0.50%	0.05%
33	Romania	0.35%	0.46%	0.11%
34	Turkey	0.34%	0.42%	0.08%
32	United Kingdom	0.35%	0.40%	0.05%
31	Ukraine	0.36%	0.39%	0.03%
36	Lithuania	0.16%	0.20%	0.04%
35	Belarus	0.17%	0.17%	0.00%
37	Bosnia and Herzegovina (*)	0.00%	0.00%	0.00%

IPv6 Matrix Project - http://www.ipv6matrix.org

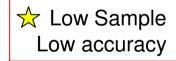Internet Society
England

Europe Trends

- Luxembourg, Norway and Germany see a significant rise in infrastructure
  - Likely to be caused by a main hosting provider, installing dual-stack Name-servers
- Slovakia & Portugal still leading with dual-stack Web sites
- Czech Republic has highest growth in dual-stack Web sites
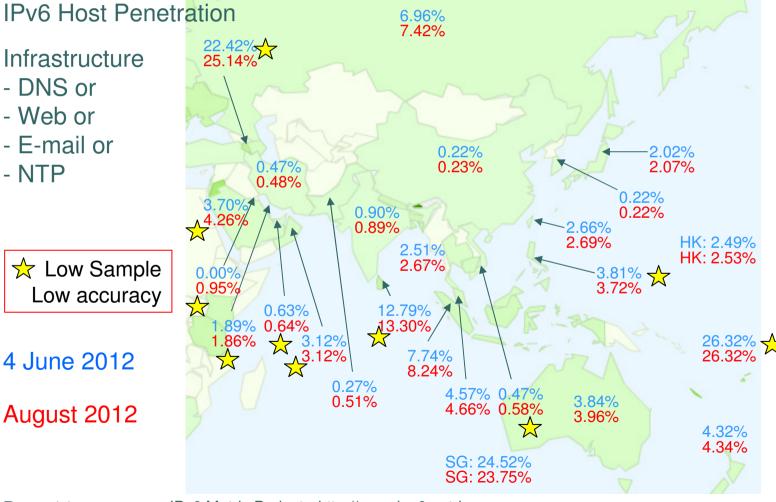- Country with largest number of dual stack Web sites in Europe: Germany

IPv6 Matrix Project - http://www.ipv6matrix.org

Internet Society
England
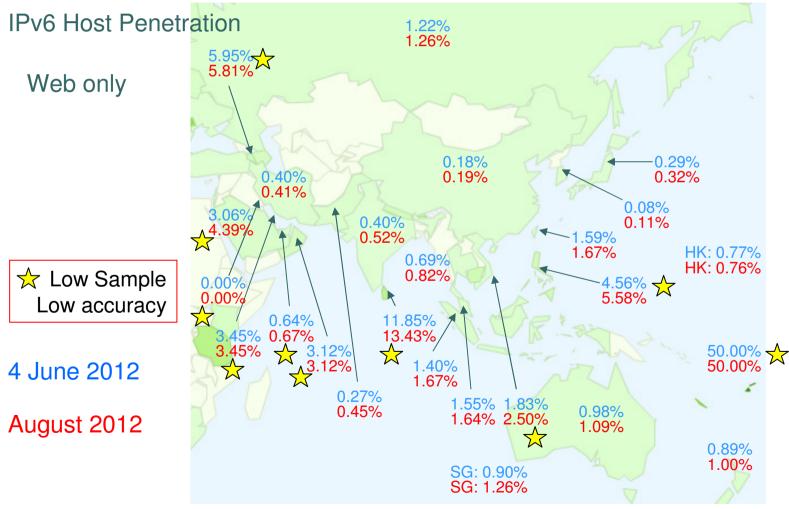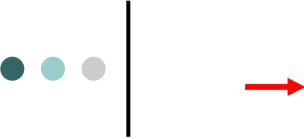
Asia Data snapshot

IPv6 Host Penetration

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

⭐ Low Sample
Low accuracy

4 June 2012

August 2012

6.96%
7.42%

22.42%
25.14% ⭐

0.47%
0.48%

3.70%
4.26% ⭐

0.00%
0.95%

1.89%
1.86% ⭐

0.63%
0.64%

3.12%
3.12% ⭐

0.27%
0.51%

0.90%
0.89%

2.51%
2.67%

0.22%
0.23%

12.79%
13.30% ⭐

7.74%
8.24%

2.66%
2.69%

0.22%
0.22%

2.02%
2.07%

HK: 2.49%
HK: 2.53%

3.81%
3.72% ⭐

4.57%
4.66%

0.47%
0.58%

3.84%
3.96%

26.32%
26.32% ⭐

4.32%
4.34%

SG: 24.52%
SG: 23.75%

IPv6 Matrix Project - http://www.ipv6matrix.org

Internet Society
England

Asia Data snapshot

IPv6 Host Penetration

Web only

⭐ Low Sample
Low accuracy

4 June 2012

August 2012

1.22%
1.26%

5.95%⭐
5.81%

0.18%
0.19%

0.29%
0.32%

0.40%
0.41%

0.08%
0.11%

3.06%
4.39%

0.40%
0.52%

1.59%
1.67%

HK: 0.77%
HK: 0.76%

0.69%
0.82%

4.56%
5.58%⭐

0.00%
0.00%

0.64%
0.67%

11.85%
13.43%⭐

50.00%
50.00%⭐

3.45%
3.45%

3.12%
3.12%

1.40%
1.67%

0.98%
1.09%

0.27%
0.45%

1.55%
1.64%

1.83%
2.50%

0.89%
1.00%

SG: 0.90%
SG: 1.26%

IPv6 Matrix Project - http://www.ipv6matrix.org

Internet Society England

IPv6 Host Penetration
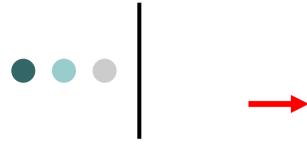
Infrastructure
- DNS or
- Web or
- E-mail or
- NTP

(*) Low Sample
Low accuracy

Previous Order	Country	DNS+WEB+E-mail+NTP		% change
		4 June 2012	August 2012	
1	Fiji (*)	26.32%	26.32%	0.00%
3	Armenia (*)	22.42%	25.14%	2.72%
2	Singapore	24.52%	23.75%	-0.77%
4	Sri Lanka (*)	12.79%	13.30%	0.51%
5	Indonesia	7.74%	8.24%	0.50%
6	Russia	6.96%	7.42%	0.46%
7	Malaysia	4.57%	4.66%	0.09%
8	New Zealand	4.32%	4.34%	0.02%
11	Saudi Arabia (*)	3.70%	4.26%	0.56%
9	Australia	3.84%	3.96%	0.12%
10	Philippines (*)	3.81%	3.72%	-0.09%
12	Oman (*)	3.12%	3.12%	0.00%
13	Taiwan	2.66%	2.69%	0.03%
14	Thailand	2.51%	2.67%	0.16%
15	Hong Kong	2.49%	2.53%	0.04%
16	Japan	2.02%	2.07%	0.05%
17	Qatar (*)	1.89%	1.86%	-0.03%
25	Kuwait (*)	0.00%	0.95%	0.95%
18	India	0.90%	0.89%	-0.01%
19	United Arab Emirates (*)	0.63%	0.64%	0.01%
21	Vietnam (*)	0.47%	0.58%	0.11%
22	Pakistan	0.27%	0.51%	0.24%
20	Iran	0.47%	0.48%	0.01%
24	China	0.22%	0.23%	0.01%
23	South Korea	0.22%	0.22%	0.00%

IPv6 Matrix Project - http://www.ipv6matrix.org

IPv6 Host Penetration

Web only

(*) Low Sample
Low accuracy

Previous Order	Country	WEB		% change
		4 June 2012	August 2012	
1	Fiji (*)	50.00%	50.00%	0.00%
2	Sri Lanka (*)	11.85%	13.43%	1.58%
3	Armenia (*)	5.95%	5.81%	-0.14%
4	Philippines (*)	4.56%	5.58%	1.02%
7	Saudi Arabia (*)	3.06%	4.39%	1.33%
5	Qatar (*)	3.45%	3.45%	0.00%
6	Oman (*)	3.12%	3.12%	0.00%
8	Taiwan	1.59%	1.67%	0.08%
10	Indonesia	1.40%	1.67%	0.27%
9	Malaysia	1.55%	1.64%	0.09%
11	Russia	1.22%	1.26%	0.04%
13	Singapore	0.90%	1.26%	0.36%
12	Australia	0.98%	1.09%	0.11%
14	New Zealand	0.89%	1.00%	0.11%
16	Thailand	0.69%	0.82%	0.13%
15	Hong Kong	0.77%	0.76%	-0.01%
17	United Arab Emirates (*)	0.64%	0.67%	0.03%
19	India	0.40%	0.52%	0.12%
21	Pakistan	0.27%	0.45%	0.18%
18	Iran	0.40%	0.41%	0.01%
20	Japan	0.29%	0.32%	0.03%
24	Vietnam (*)	0.07%	0.24%	0.17%
22	China	0.18%	0.19%	0.01%
23	South Korea	0.08%	0.11%	0.03%
25	Kuwait (*)	0.00%	0.00%	0.00%

IPv6 Matrix Project - http://www.ipv6matrix.org

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Asia Trends

- Singapore still leading by far in infrastructure but trailing in dual-stack Web Site content
- Armenia growth in infrastructure
- 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
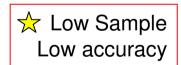- Less reliability of results due to smaller sample size in many countries of the region
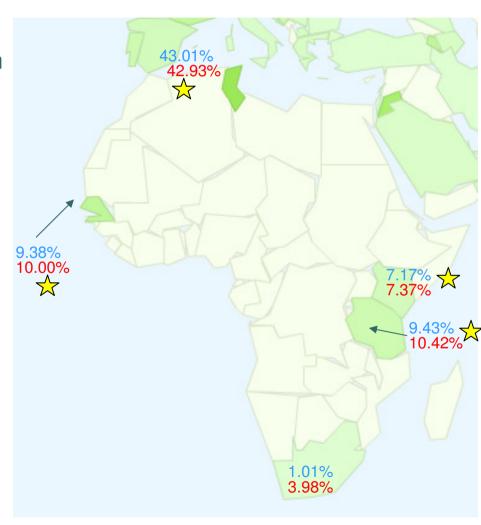
IPv6 Matrix Project - http://www.ipv6matrix.org

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Africa Data snapshot

IPv6 Host Penetration

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

⭐ Low Sample
Low accuracy

4 June 2012

August 2012

43.01%
42.93%

9.38%
10.00%

7.17%
7.37%

9.43%
10.42%

1.01%
3.98%

IPv6 Matrix Project - http://www.ipv6matrix.org

Internet Society England

Africa Data snapshot

IPv6 Host Penetration

Web only

⭐ Low Sample
Low accuracy

4 June 2012

August 2012

0.00%
0.00%

0.00%
0.00%

2.56%
4.88%

14.29%
16.67%

0.46%
0.51%

IPv6 Matrix Project - http://www.ipv6matrix.org

IPv6 Host Penetration

Infrastructure
- DNS or
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- NTP
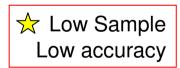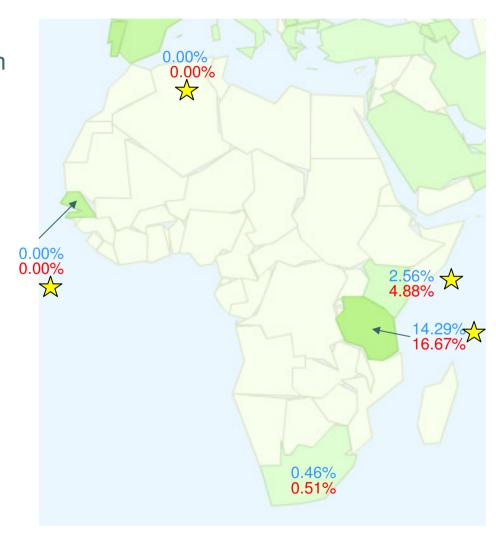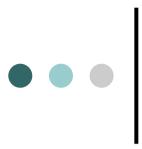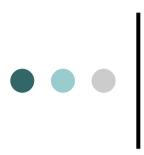
(*) Low Sample
Low accuracy

		Country	DNS+WEB+E-mail+NTP		% change
			4 June 2012	August 2012	
1	Tunisia (*)		43.01%	42.93%	-0.08%
2	Tanzania (*)		9.43%	10.42%	0.99%
3	Senegal (*)		9.38%	10.00%	0.62%
4	Kenya (*)		7.17%	7.37%	0.20%
5	South Africa		1.01%	3.98%	2.97%
6	Algeria		0.96%	0.00%	-0.96%

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

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IPv6 Host Penetration

Web only

	Country	WEB		% change
		4 June 2012	August 2012	
1	Tanzania (*)	14.29%	16.67%	2.38%
2	Kenya (*)	2.56%	4.88%	2.32%
3	Algeria	1.28%	0.00%	-1.28%
4	South Africa	0.46%	0.51%	0.05%
5	Senegal (*)	0.00%	0.00%	0.00%
6	Tunisia (*)	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

IPv6 Matrix Project - http://www.ipv6matrix.org
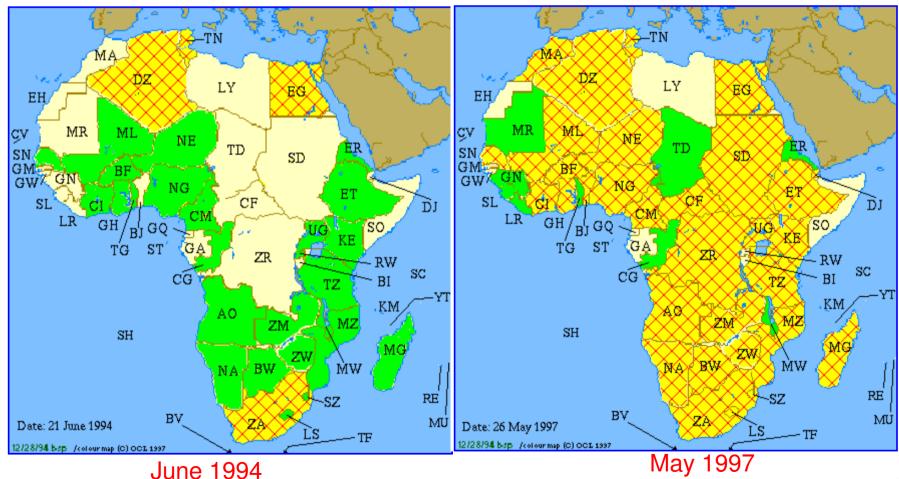
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Africa Trends

- Many countries now have IPv6 capability, some through tunnels
- South Africa has fastest growth in infrastructure in this period
- Dual Stack Islands starting to appear
- Can be compared with the growth of Internet connectivity in the nineties

IPv6 Matrix Project - http://www.ipv6matrix.org

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Compare Historical data on African Internet Connectivity

June 1994

May 1997

IPv6 Matrix Project - http://www.ipv6matrix.org

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North/South America

IPv6 Host Penetration

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

⭐ Low Sample
Low accuracy

4 June 2012

August 2012

3.30%
4.64%

6.17%
11.46%

3.57% ⭐
3.53%

PR: 6.67% ⭐
PR: 9.09%

0.80%
0.86%

4.35% ⭐
4.60%

1.09%
1.40% ⭐

5.89%
5.92%

1.14% ⭐
1.17%

4.44%
4.09% ⭐

0.72% ⭐
1.60%

3.42% ⭐
3.48%

5.36% ⭐
5.63%

0.56%
5.95%

0.49%
0.89%

IPv6 Matrix Project - http://www.ipv6matrix.org

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North/South America

IPv6 Host Penetration

Web only

⭐ Low Sample
Low accuracy

4 June 2012

August 2012

0.61%
0.58%

0.20%
11.79%

PR: 6.67%
PR: 7.14%

1.83%
2.50%

1.03%
1.13%

1.45%
1.51%

0.58%
0.59%

2.66%
2.64%

8.75%
8.00%

0.95%
0.95%

2.71%
2.78%

0.35%
0.51%

2.73%
4.63%

0.56%
0.56%

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IPv6 Host Penetration

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

(*) Low Sample
Low accuracy
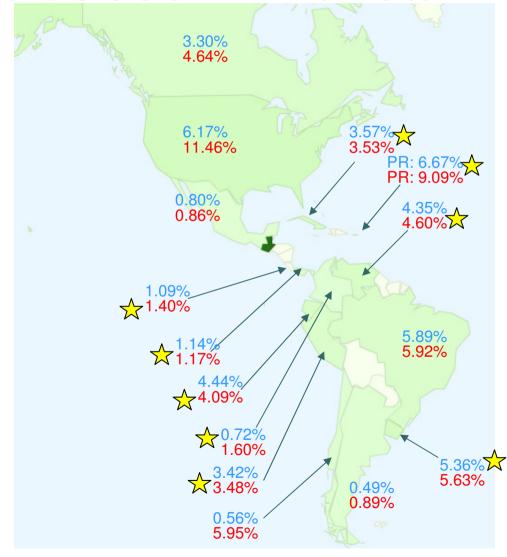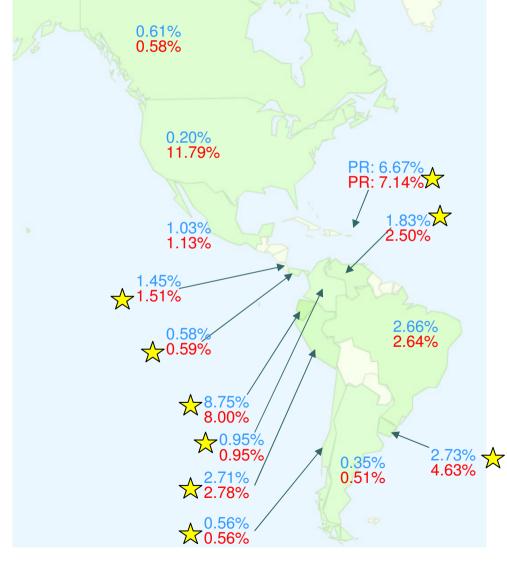
Previous Order	Country	DNS+WEB+E-mail+NTP		% change
		4 June 2012	August 2012	
2	United States	6.17%	11.46%	5.29%
1	Puerto Rico (*)	6.67%	9.09%	2.42%
14	Chile	0.56%	5.95%	5.39%
3	Brasil	5.89%	5.92%	0.03%
4	Uruguay (*)	5.36%	5.63%	0.27%
9	Canada	3.30%	4.64%	1.34%
6	Venezuela (*)	4.35%	4.60%	0.25%
5	Ecuador (*)	4.44%	4.09%	-0.35%
7	Cuba (*)	3.57%	3.53%	-0.04%
8	Peru (*)	3.42%	3.48%	0.06%
13	Colombia (*)	0.72%	1.60%	0.88%
11	Costa Rica	1.09%	1.40%	0.31%
10	Panama (*)	1.14%	1.17%	0.03%
15	Argentina	0.49%	0.89%	0.40%
12	Mexico	0.80%	0.86%	0.06%
16	Guatemala (*)	0.00%	0.00%	0.00%

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

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IPv6 Host Penetration

Web only

(*) Low Sample
Low accuracy

Previous Order	Country	WEB 4 June 2012	August 2012	% change
14	United States	0.20%	11.79%	11.59%
1	Ecuador (*)	8.75%	8.00%	-0.75%
2	Puerto Rico (*)	6.67%	7.14%	0.47%
3	Uruguay (*)	2.73%	4.63%	1.90%
4	Peru (*)	2.71%	2.78%	0.07%
5	Brasil	2.66%	2.64%	-0.02%
6	Venezuela (*)	1.83%	2.50%	0.67%
7	Costa Rica	1.45%	1.51%	0.06%
8	Mexico	1.03%	1.13%	0.10%
9	Colombia (*)	0.95%	0.95%	0.00%
11	Panama (*)	0.58%	0.59%	0.01%
10	Canada	0.61%	0.58%	-0.03%
12	Chile	0.56%	0.56%	0.00%
13	Argentina	0.35%	0.51%	0.16%
15	Guatemala (*)	0.00%	0.00%	0.00%
16	Cuba (*)	0.00%	0.00%	0.00%

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

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America Trends

- USA has a significant jump in growth both in infrastructure and also in dual-stack Web sites. This appears to be directly related to the World IPv6 Launch

- Chile shows significant growth in infrastructure

- Canada trailing in dual-stack Web sites

- 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)

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Worldwide Trends

○ We are still seeing a slow 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 has shown the fasted growth in this period, a direct result of World IPv6 Launch.

○ Some small countries like Luxembourg have had their main ISPs switch onto dual stack thus showing growth in dual-stack infrastructure

○ Bearing in mind the Asia Pacific Regional Internet Registry has run out of IPv4 addresses, it is still alarming to see so few Web sites up and running IPv6 in that region, especially in countries where Internet growth is high, such as India. World IPv6 Day appears to have had no impact on those countries.

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Possible errors / Caveats

- 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

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Future work / funding required

○ 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

○ Duplication of Crawler to other regions

IPv6 Matrix Project - http://www.ipv6matrix.org

Thank you

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

IPv6 Matrix Project - http://www.ipv6matrix.org