# • • IPv6 Matrix Project

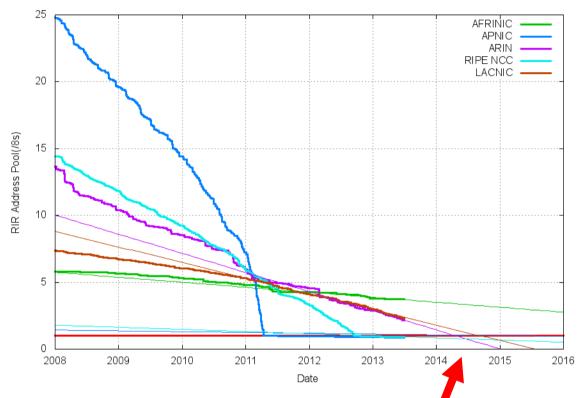
Tracking IPv6 connectivity Worldwide <a href="http://www.ipv6matrix.org">http://www.ipv6matrix.org</a>

Dr. Olivier MJ Crépin-Leblond — <a href="mailto:ocl@gih.com">ocl@gih.com</a>
June 2013 Update 1 year after World IPv6 Launch of 2012



### 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 June 2012



### • • 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.



## • • 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



## • • Project Teams

- o London, UK:
  - Project Management and support
  - Hardware supply and installation
  - Data Centre and IPv6 connectivity
- o Nile University, Egypt:
  - Software Programming



## • • Crawler



Crawler (back end)	
Model	HP DL360p
Name (eth0)	turtle.ipv6matrix.org; crawler.ipv6matrix.org turtle.ipv6matrix.com; crawler.ipv6matrix.com turtle.ipv6matrix.net; crawler.ipv6matrix.net
IPv4 address (eth0) / speed	212.124.204.162 / 100 Mb/s
IPv6 address (eth0) / speed	2a00:19e8:20:1::a2 / 100 Mb/s
Name (eth1)	shell.ipv6matrix.org
IPv4 address (eth1) / speed	194.33.63.250 / 1 Gb/s (GIH private address space)
CPU	2 x Dual Core Intel(R) Xeon(TM) CPU 3.60GHz
RAM	4 Gb DDR2 SDRAM
HD Storage	146 Gb hardware SATA 2-disk RAID (hot swappable)
PSU	2 x hot-swappable redundant 535W.
Operating System	CENTOS 5 Linux / updated

## • • Web Server



Web Server (front end)	
Model	HP DL140
Name (eth0)	elephant.ipv6matrix.org; www.ipv6matrix.org elephant.ipv6matrix.com; www.ipv6matrix.com elephant.ipv6matrix.net; www.ipv6matrix.net
IPv4 address (eth0) / speed	212.124.204.170 / 100 Mb/s
IPv6 address (eth0) / speed	2a00:19e8:20:1::aa / 100 Mb/s
Name (eth1)	tusk.ipv6matrix.org
IPv4 address (eth1) / speed	194.33.63.251 / 1 Gb/s (GIH private address space)
CPU	2 x Dual Core Intel(R) Xeon(TM) CPU 3.40GHz
RAM	4 Gb DDR2 SDRAM
HD Storage	2 x 1 Tb fast SATA
PSU	Single 500W
Operating System	Ubuntu 4.4 Linux / updated



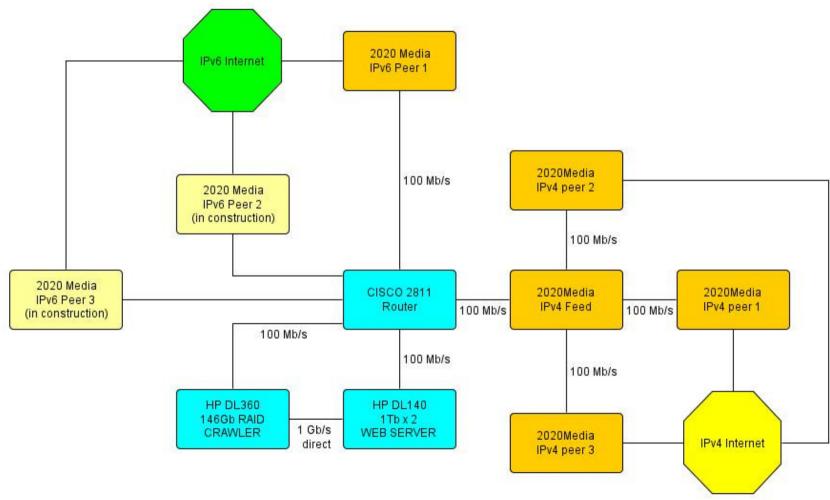
## • • Router



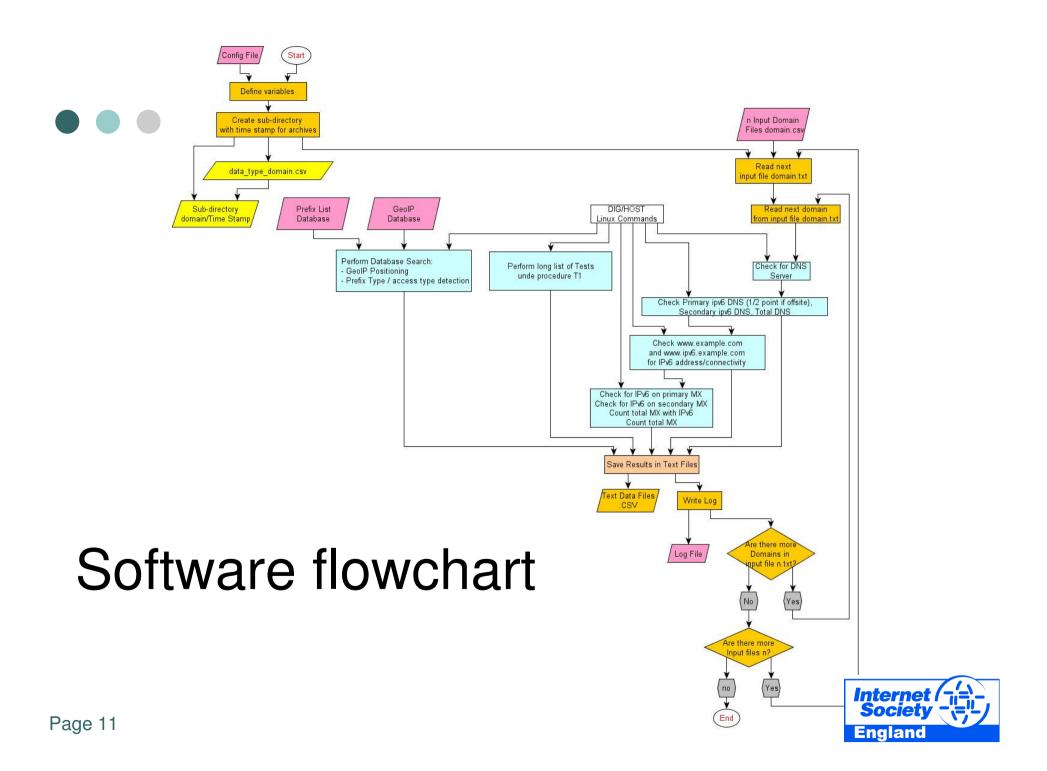
Router	
Model	CISCO 2811
Operating System	Advanced IP Services IOS
DRAM	64 Mb
Ethernet Ports / speed	2 / 100 Mb/s
Interface card / speed	MN-16ESW 16 port / 100 Mb/s

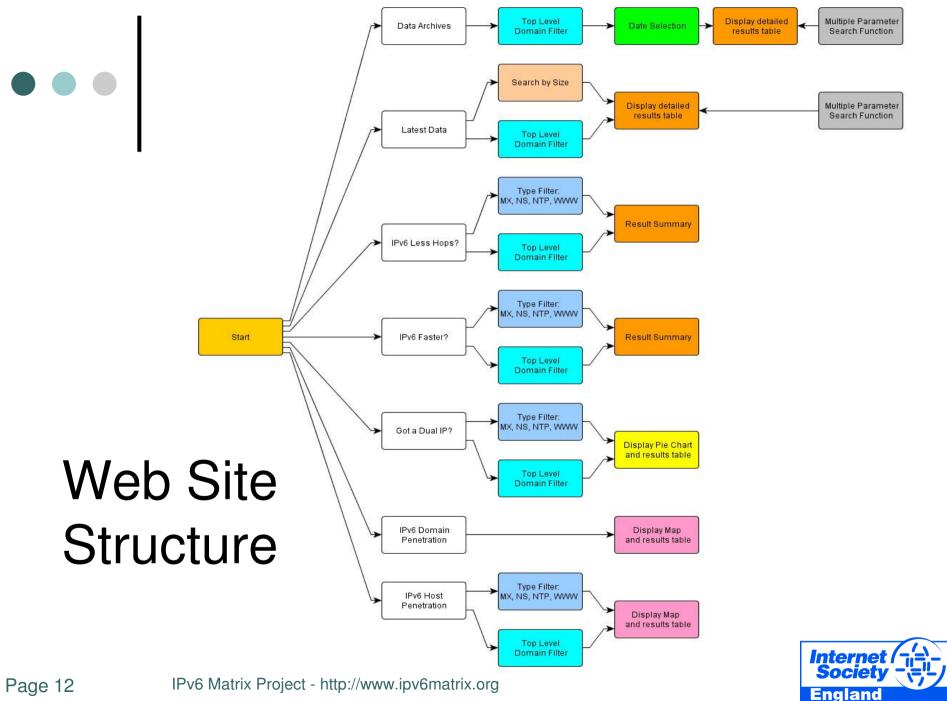


## • • Local Network

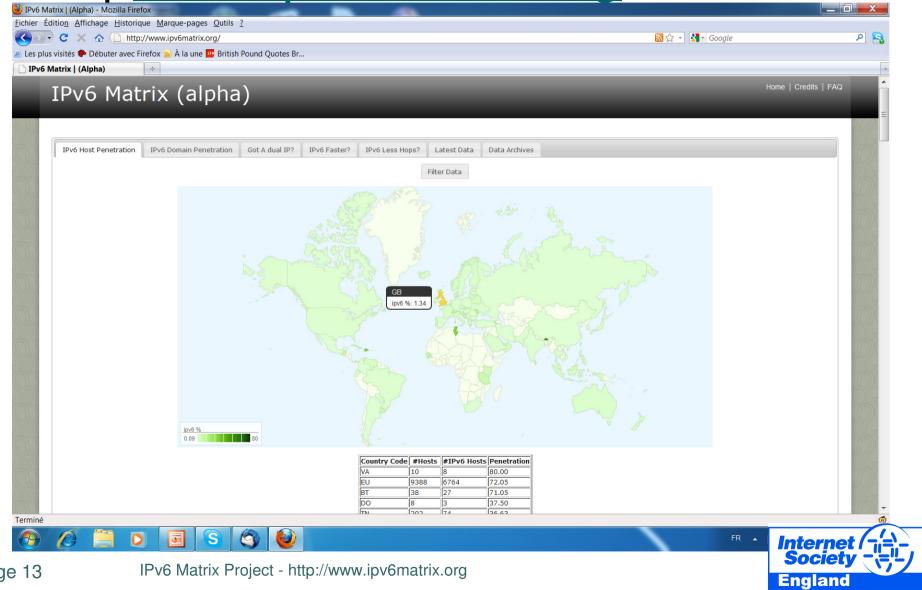








### www.ipv6matrix.org Web Site



## • • 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

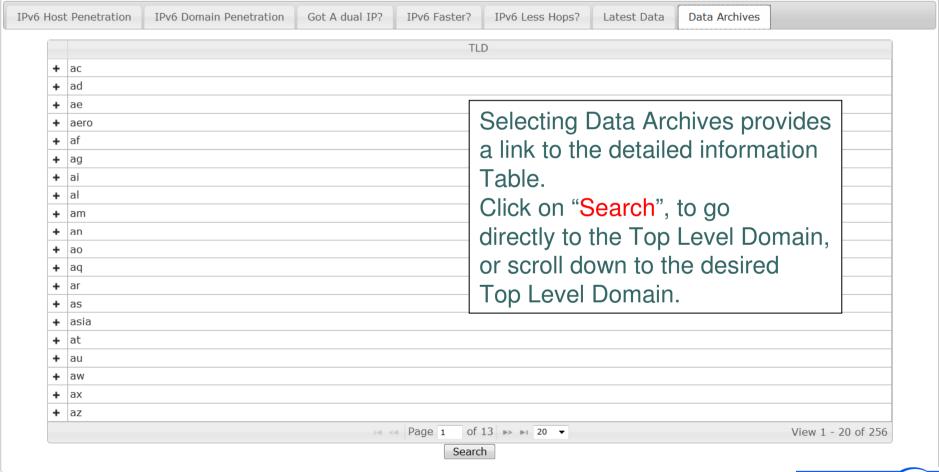


## • • What are we archiving?

- 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)

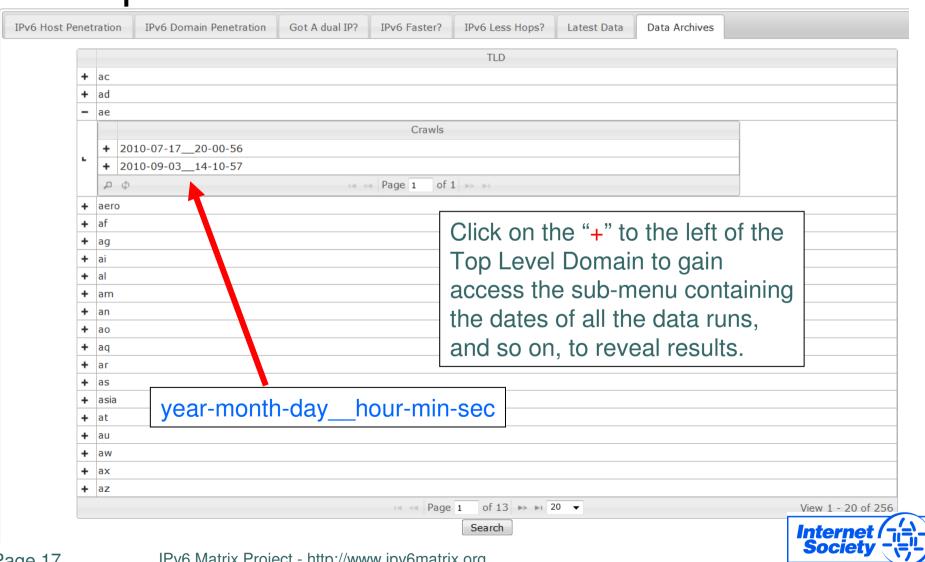


### • • Data Archives



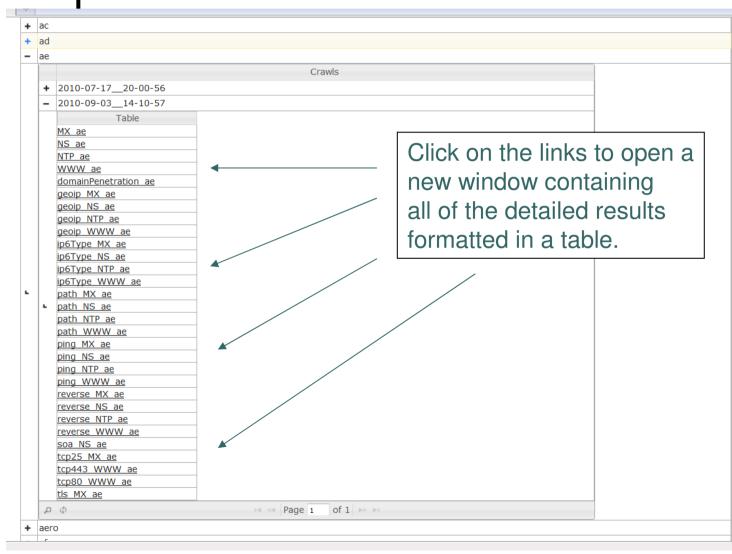


### Data Archives



England

### Data Archives - results



**England** 

### Data Archives - results

Basic IPv4/IPv6 connectivity table

Domain penetration summary table

Geographical IP database

Type of IPv6 access (tunnels etc.)

Trace path, hop count, MTU IPv4 & IPv6

Ping count IPv4 and IPv6

Reverse IPv4 and IPv6

**SOA** for Nameserver

Service detection for SMTP, HTTP and HTTPs

TLS detection for SMTP



+ 2010-07-17\_\_20-50-56

14-10-57

**-** 2010-09-03

geoip NS ae geoip NTP ae geoip WWW ae

ip6Type NS ae ip6Type NTP ae ip6Type WWW ae

path NS ae path NTP ae

ping NTP ae ping WWW ae

soa NS ae

reverse NS ae

tcp443 WWW ae tcp80 WWW ae

MX ae

NS ae

NTP ae

WWW ae



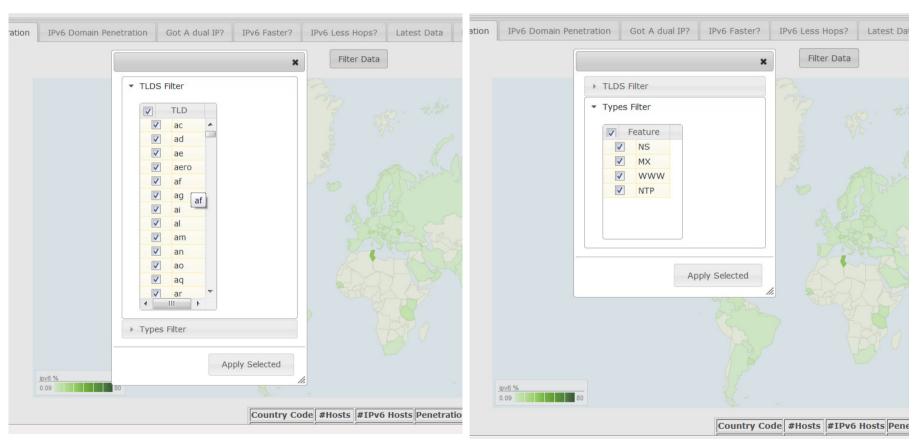


type 🌲	domain	host	port	ipv4	ipv6	tcp	tcp6
cp80	google.ae	www.google.ae	80	173.194.36.104	n/a	True	n/a
tcp80	travian.ae	www.travian.ae	80	92.51.158.104	n/a	True	n/a
tcp80	travian.ae	www6.travian.ae	80	92.51.158.104	n/a	True	n/a
tcp80	travian.ae	ipv6.travian.ae	80	92.51.158.104	n/a	True	n/a
tcp80	travian.ae	www.ipv6.travian.ae	80	92.51.158.104	n/a	True	n/a
tcp80	travian.ae	six.travian.ae	80	92.51.158.104	n/a	True	n/a
tcp80	tribalwars.ae	www.tribalwars.ae	80	212.48.106.45	n/a	True	n/a
tcp80	tribalwars.ae	www6.tribalwars.ae	80	212.48.106.45	n/a	True	n/a
tcp80	tribalwars.ae	ipv6.tribalwars.ae	80	212.48.106.45	n/a	True	n/a
tcp80	tribalwars.ae	www.ipv6.tribalwars.a	80	212.48.106.45	n/a	True	n/a
tcp80	tribalwars.ae	six.tribalwars.ae	80	212.48.106.45	n/a	True	n/a
tcp80	etisalat.ae	www.etisalat.ae	80	195.229.236.144	n/a	True	n/a
tcp80	eim.ae	www.eim.ae	80	195.229.240.230	n/a	True	n/a
tcp80	khanwars.ae	www.khanwars.ae	80	188.40.91.79	n/a	True	n/a
tcp80	khanwars.ae	www6.khanwars.ae	80	188.40.91.79	n/a	True	n/a
tcp80	khanwars.ae	ipv6.khanwars.ae	80	188.40.91.79	n/a	True	n/a
tcp80	khanwars.ae	www.ipv6.khanwars.a	80	188.40.91.79	n/a	True	n/a
tcp80	khanwars.ae	six.khanwars.ae	80	188.40.91.79	n/a	True	n/a
tcp80	sez.ae	www.sez.ae	80	74.86.113.208	n/a	True	n/a
tcp80	thenational.ae	www.thenational.ae	80	205.139.40.94	n/a	True	n/a





### Using the filter



Use the filter to select by Top Level Domain, or by type of service tested.





June 2013 1 Year after IPv6 Launch Day



### Europe Data snapshot

**IPv6 Host Penetration** 

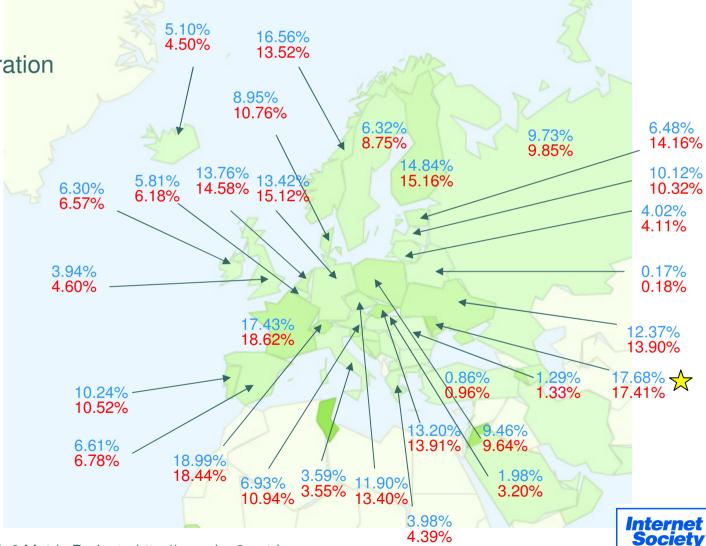
#### Infrastructure

- DNS
- Web
- E-mail
- NTP

★ Low Sample Low accuracy

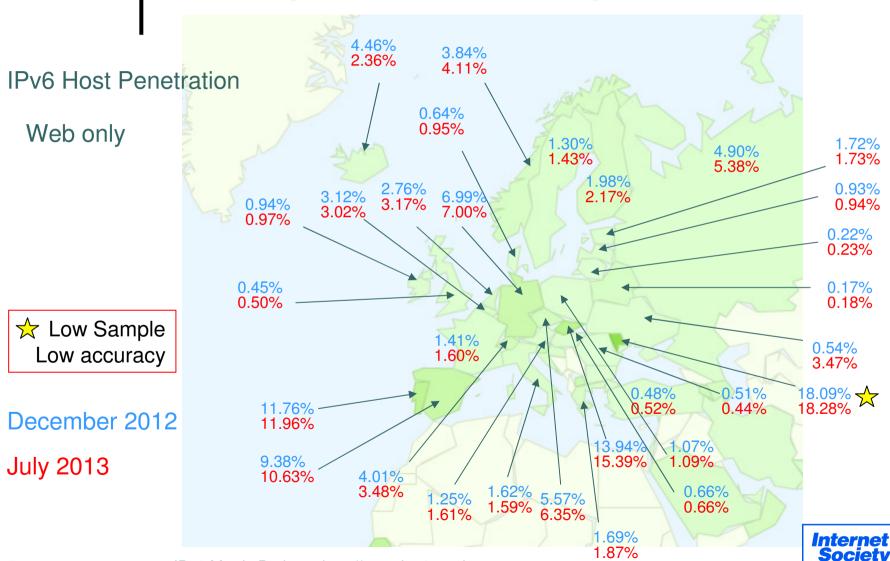
December 2012

June 2013



England

### Europe Data snapshot



**England** 



#### IPv6 Host Penetration

#### Infrastructure

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

(\*) Low Sample Low accuracy

Previous	Country	DNS+WEB+E-mail+NTP		% change
Order		Dec 2012	June 2013	
1	Luxembourg	59.14%	61.58%	2.44%
4	France	17.43%	18.62%	1.19%
2	Switzerland	18.99%	18.44%	-0.55%
3	Moldova (*)	17.68%	17.41%	-0.27%
7	Finland	14.84%	15.16%	0.32%
10	Germany	13.42%	15.12%	1.70%
6	Liechtenstein	15.38%	15.00%	-0.38%
8	Slovenia	13.81%	14.87%	1.06%
9	Netherlands	13.76%	14.58%	0.82%
23	Estonia	6.48%	14.16%	7.68%
11	Slovakia	13.20%	13.91%	0.71%
12	Ukraine	12.37%	13.90%	1.53%
5	Norway	16.56%	13.52%	-3.04%
13	Czech Republic	11.90%	13.40%	1.50%
21	Austria	6.93%	10.94%	4.01%
18	Denmark	8.95%	10.76%	1.81%
14	Portugal	10.24%	10.52%	0.28%
15	Latvia	10.12%	10.32%	0.20%
16	Russia	9.73%	9.85%	0.12%
17	Poland	9.46%	9.64%	0.18%
24	Sweden	6.32%	8.75%	2.43%
19	Croatia	7.40%	7.55%	0.15%
22	Spain	6.61%	6.78%	0.17%
25	Ireland	6.30%	6.57%	0.27%
26	Bulgaria	5.86%	6.51%	0.65%
27	Belgium	5.81%	6.18%	0.37%
20	Bosnia and Herzegovina (*)	7.07%	6.09%	-0.98%
29	Macedonia	4.52%	5.40%	0.88%
32	United Kingdom	3.94%	4.60%	0.66%
28	Iceland	5.10%	4.50%	-0.60%
31	Greece	3.98%	4.39%	0.41%
30	Lithuania	4.02%	4.11%	0.09%
33	Italy	3.59%	3.55%	-0.04%
34	Serbia (*)	3.07%	3.30%	0.23%
35	Hungary	1.98%	3.20%	1.22%
36	Romania	1.29%	1.33%	0.04%
37	Turkey	0.86%	0.96%	0.10%





#### **IPv6 Host Penetration**

Web only

(\*) Low Sample Low accuracy

Previous	Country	WEB		% change
Order		Dec 2012	June 2013	
1	Moldova (*)	18.09%	18.28%	0.19%
2	Slovakia	13.94%	15.39%	1.45%
3	Portugal	11.76%	11.96%	0.20%
4	Spain	9.38%	10.63%	1.25%
5	Germany	6.99%	7.00%	0.01%
7	Czech Republic	5.57%	6.35%	0.78%
6	Slovenia	5.86%	6.00%	0.14%
8	Russia	4.90%	5.38%	0.48%
10	Macedonia	4.12%	5.21%	1.09%
12	Norway	3.84%	4.11%	0.27%
11	Switzerland	4.01%	3.48%	-0.53%
30	Ukraine	0.54%	3.47%	2.93%
15	Netherlands	2.76%	3.17%	0.41%
13	Luxembourg	3.74%	3.12%	-0.62%
14	Belgium	3.12%	3.02%	-0.10%
16	Croatia	2.56%	2.63%	0.07%
9	Iceland	4.46%	2.36%	-2.10%
17	Finland	1.98%	2.17%	0.19%
20	Greece	1.69%	1.87%	0.18%
19	Estonia	1.72%	1.73%	0.01%
18	Serbia (*)	1.78%	1.63%	-0.15%
24	Austria	1.25%	1.61%	0.36%
22	France	1.41%	1.60%	0.19%
21	Italy	1.62%	1.59%	-0.03%
23	Sweden	1.30%	1.43%	0.13%
25	Poland	1.07%	1.09%	0.02%
26	Ireland	0.94%	0.97%	0.03%
29	Denmark	0.64%	0.95%	0.31%
27	Latvia	0.93%	0.94%	0.01%
28	Hungary	0.66%	0.66%	0.00%
33	Bulgaria	0.45%	0.55%	0.10%
32	Turkey	0.48%	0.52%	0.04%
34	United Kingdom	0.45%	0.50%	0.05%
31	Romania	0.51%	0.44%	-0.07%
35	Lithuania	0.22%	0.23%	0.01%
36	Belarus	0.17%	0.18%	0.01%
37	Bosnia and Herzegovina (*)	0.00%	0.00%	0.00%
38	Liechtenstein	0.00%	0.00%	0.00%

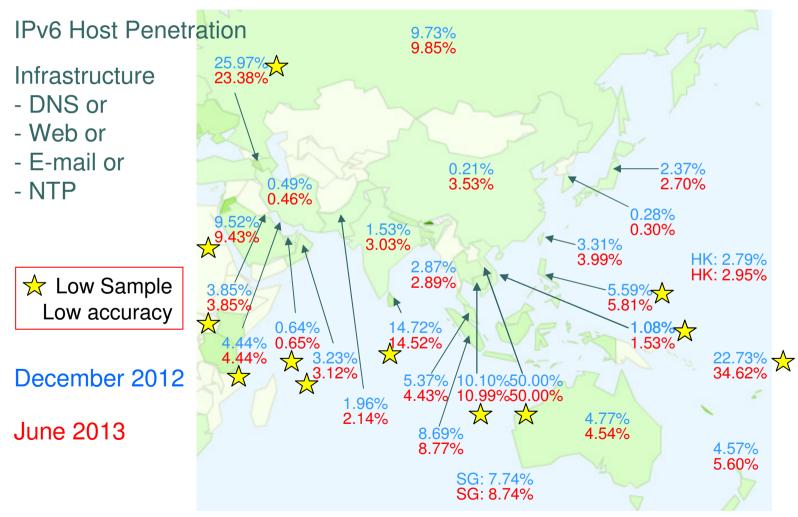


## • • Europe Trends

- Countries see a steady rise in infrastructure
  - Although growth is not accelerating
- Estonia with biggest growth in infrastructure
- Slovakia & Portugal still leading growth with dual-stack Web sites
- Spain catching up with high growth.
- Country with largest number of dual stack
   Web sites in Europe: Germany

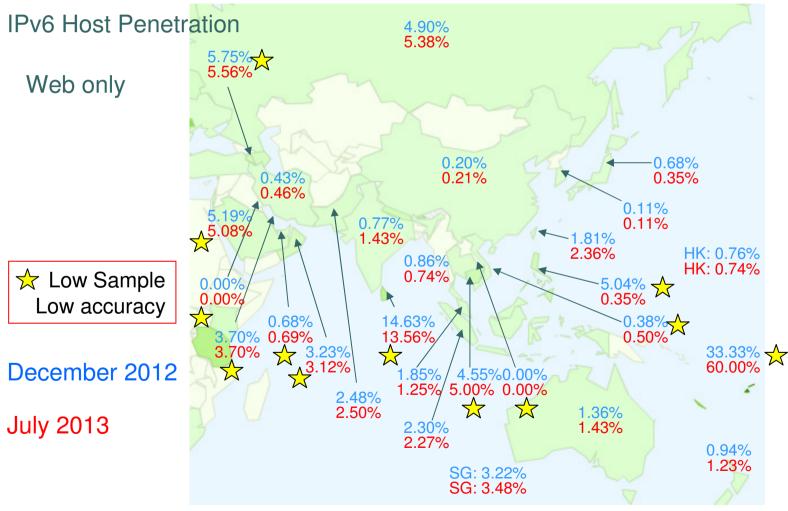


### Asia Data snapshot





### Asia Data snapshot







#### **IPv6 Host Penetration**

#### Infrastructure

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

(\*) Low Sample Low accuracy

Previous	Previous Country DNS+WEB+E-mail+NTF		E-mail+NTP	% change
Order		Dec 2012	June 2013	
1	Laos PDR (*)	50.00%	50.00%	0.00%
3	Fiji (*)	22.73%	34.62%	11.89%
2	Armenia (*)	25.97%	23.38%	-2.59%
4	Sri Lanka (*)	14.72%	14.52%	-0.20%
5	Cambodia (*)	10.10%	10.99%	0.89%
6	Russia	9.73%	9.85%	0.12%
7	Saudi Arabia (*)	9.52%	9.43%	-0.09%
8	Indonesia	8.69%	8.77%	0.08%
9	Singapore	7.74%	8.74%	1.00%
10	Philippines (*)	5.59%	5.81%	0.22%
13	New Zealand	4.57%	5.60%	1.03%
12	Australia	4.77%	4.54%	-0.23%
14	Qatar (*)	4.44%	4.44%	0.00%
11	Malaysia	5.37%	4.43%	-0.94%
16	Taiwan	3.31%	3.99%	0.68%
15	Kuwait (*)	3.85%	3.85%	0.00%
27	China	0.21%	3.53%	3.32%
17	Oman (*)	3.23%	3.12%	-0.11%
22	India	1.53%	3.03%	1.50%
19	Hong Kong	2.79%	2.95%	0.16%
18	Thailand	2.87%	2.89%	0.02%
20	Japan	2.37%	2.70%	0.33%
21	Pakistan	1.96%	2.14%	0.18%
23	Vietnam (*)	1.08%	1.53%	0.45%
24	United Arab Emirates (*)	0.64%	0.65%	0.01%
25	Iran	0.49%	0.46%	-0.03%
26	South Korea	0.28%	0.30%	0.02%





#### **IPv6 Host Penetration**

Web only

(\*) Low Sample Low accuracy

Previous	Country	WEB		% change
Order		Dec 2012	June 2013	
1	Fiji (*)	33.33%	60.00%	26.67%
2	Sri Lanka (*)	14.63%	13.56%	-1.07%
3	Armenia (*)	5.75%	5.56%	-0.19%
6	Russia	4.90%	5.38%	0.48%
4	Saudi Arabia (*)	5.19%	5.08%	-0.11%
7	Cambodia (*)	4.55%	5.00%	0.45%
8	Qatar (*)	3.70%	3.70%	0.00%
10	Singapore	3.22%	3.48%	0.26%
9	Oman (*)	3.23%	3.12%	-0.11%
11	Pakistan	2.48%	2.50%	0.02%
14	Taiwan	1.81%	2.36%	0.55%
12	Indonesia	2.30%	2.27%	-0.03%
15	Australia	1.36%	1.43%	0.07%
18	India	0.77%	1.43%	0.66%
13	Malaysia	1.85%	1.25%	-0.60%
16	New Zealand	0.94%	1.23%	0.29%
17	Thailand	0.86%	0.74%	-0.12%
19	Hong Kong	0.76%	0.74%	-0.02%
20	United Arab Emirates (*)	0.68%	0.69%	0.01%
23	Vietnam (*)	0.38%	0.50%	0.12%
22	Iran	0.43%	0.46%	0.03%
5	Philippines (*)	5.04%	0.35%	-4.69%
21	Japan	0.68%	0.35%	-0.33%
24	China	0.20%	0.21%	0.01%
25	South Korea	0.11%	0.11%	0.00%
26	Kuwait (*)	0.00%	0.00%	0.00%
27	Laos PDR (*)	0.00%	0.00%	0.00%



## • • Asia Trends

- Russia leading the region
- China with biggest growth in infrastructure
- China Dual Stack Web sites still very low
- India also low both in infrastructure and most popular Web sites with dual stack although infrastructure is picking up
- Less reliability of results due to smaller sample size in many countries of the region

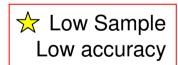


### • • Africa Data snapshot

#### **IPv6 Host Penetration**

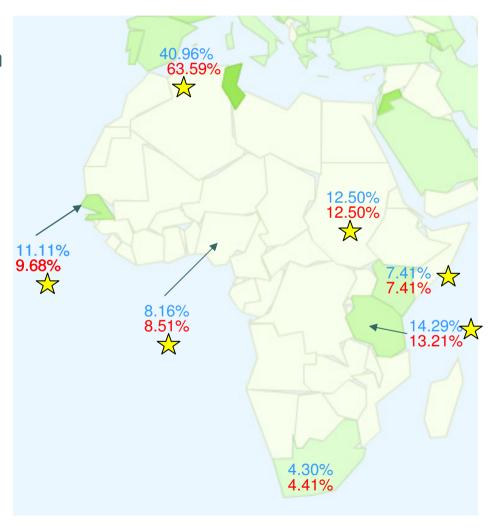
#### Infrastructure

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



December 2012

June 2013





## • • Africa Data snapshot

**IPv6 Host Penetration** 

Web only

★ Low Sample Low accuracy

December 2012

July 2013





#### **IPv6** Host Penetration

#### Infrastructure

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

(\*) Low Sample Low accuracy

Country	DNS+WEB+E	% change	
	Dec 2012	June 2013	
Tunisia (*)	40.96%	63.59%	22.63%
Tanzania (*)	14.29%	13.21%	-1.08%
Sudan (*)	12.50%	12.50%	0.00%
Senegal (*)	11.11%	9.68%	-1.43%
Nigeria (*)	8.16%	8.51%	0.35%
Kenya (*)	7.41%	7.41%	0.00%
South Africa	4.30%	4.41%	0.11%
Algeria	1.57%	0.00%	-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

(\*) Low Sample Low accuracy

Country	WEB		% change
	Dec 2012	July 2013	
Tanzania (*)	20.00%	25.00%	5.00%
Nigeria (*)	20.00%	20.00%	0.00%
Kenya (*)	2.63%	2.70%	0.07%
South Africa	0.60%	0.63%	0.03%
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%

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

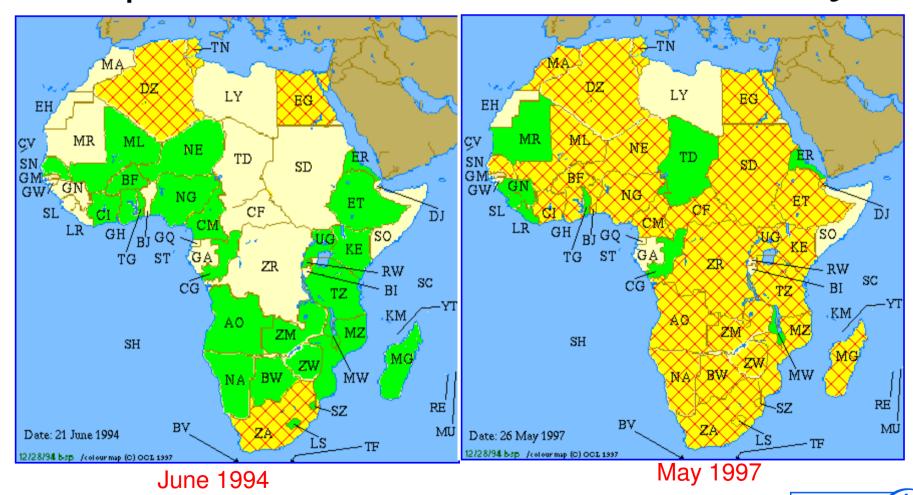


## • • Africa Trends

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



# Compare Historical data on African Internet Connectivity



England

Source: Internetology - http://www.nsrc.org/codes/bymap/ntlgy/ntlgy.htm Page 38 IPv6 Matrix Project - http://www.ipv6matrix.org

#### North/South America

#### **IPv6** Host Penetration

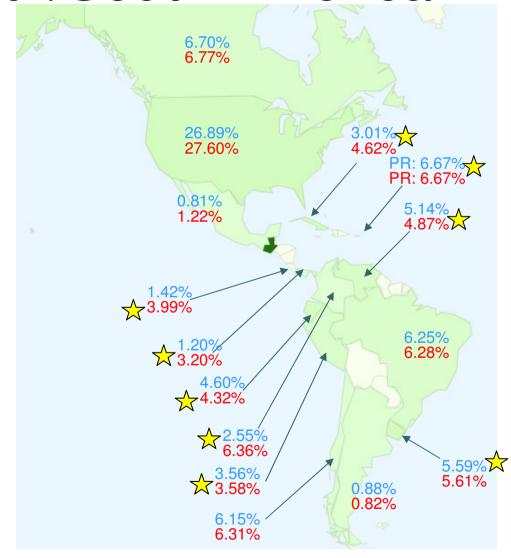
#### Infrastructure

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

★ Low Sample
 Low accuracy

December 2012

June 2013





### North/South America

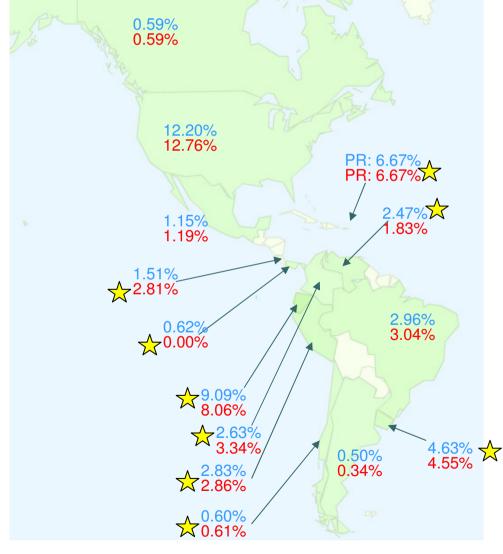
**IPv6 Host Penetration** 

Web only

★ Low Sample
 Low accuracy

December 2012

July 2013







**IPv6 Host Penetration** 

#### Infrastructure

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

Previous	Country	DNS+WEB+E	% change	
Order		Dec 2012	June 2013	
1	United States	26.89%	27.60%	0.71%
2	Canada	6.70%	6.77%	0.07%
3	Puerto Rico (*)	6.67%	6.67%	0.00%
11	Colombia (*)	2.55%	6.36%	3.81%
5	Chile	6.15%	6.31%	0.16%
4	Brasil	6.25%	6.28%	0.03%
6	Uruguay (*)	5.59%	5.61%	0.02%
7	Venezuela (*)	5.14%	4.87%	-0.27%
10	Cuba (*)	3.01%	4.62%	1.61%
8	Ecuador (*)	4.60%	4.32%	-0.28%
12	Costa Rica	1.42%	3.99%	2.57%
9	Peru (*)	3.56%	3.58%	0.02%
13	Panama (*)	1.20%	3.20%	2.00%
15	Mexico	0.81%	1.22%	0.41%
14	Argentina	0.88%	0.82%	-0.06%
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

(\*) Low Sample Low accuracy

Previous	Country	WEB		% change
Order		Dec 2012	June 2013	
1	United States	12.20%	12.76%	0.56%
2	Ecuador (*)	9.09%	8.06%	-1.03%
3	Puerto Rico (*)	6.67%	6.67%	0.00%
4	Uruguay (*)	4.63%	4.55%	-0.08%
7	Colombia (*)	2.63%	3.34%	0.71%
5	Brasil	2.96%	3.04%	0.08%
6	Peru (*)	2.83%	2.86%	0.03%
9	Costa Rica	1.51%	2.81%	1.30%
8	Venezuela (*)	2.47%	1.83%	-0.64%
10	Mexico	1.15%	1.19%	0.04%
12	Chile	0.60%	0.61%	0.01%
13	Canada	0.59%	0.59%	0.00%
14	Argentina	0.50%	0.34%	-0.16%
11	Panama (*)	0.62%	0.00%	-0.62%
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



## • • America Trends

- USA leads in infrastructure but low on dual Stack Web site although a growing figure
- Brasil shows slowdown in growth
- Costa Rica shows growth
- 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 continued 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)
- In our sample, the USA now have the largest numbers of dual stack hosts (104748 out of 820769 = 12.76%) followed by Germany (15638 out of 223546 = 7%)
- 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.
- Worldwide dual stack penetration on domains is 7.17%

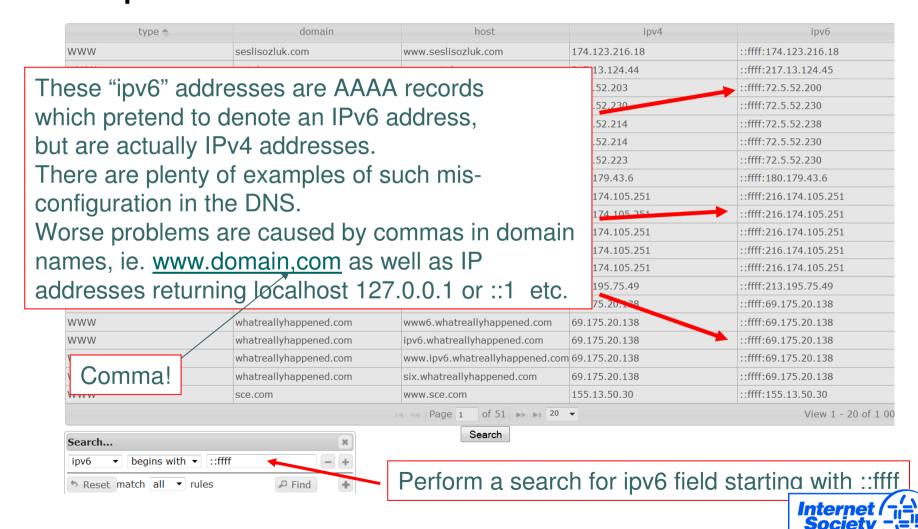


# • • Problems / Possible Errors

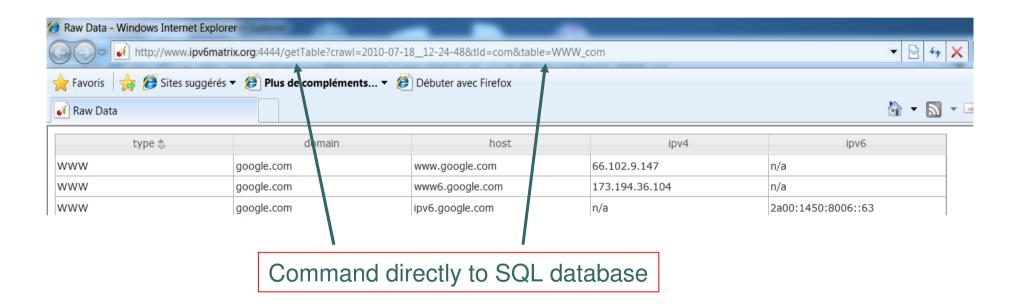
- Lots of errors in the DNS commas, no A, no AAAA record, looping MX, etc.
- Firewalls and security software:
  - Blocking of network segments
  - detecting denial of service attack (DoS) by error:
    - Unusual UDP traffic. Trace-path / ping, SMTP, HTTP, Secure HTTP, NTP port testing.
- Internet snapshot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



#### Example: fake IPv6 AAAA record



### Machine readable output



http://www.ipv6matrix.org:4444/getTable?crawl=2010-07-18\_12-24-48&tld=com&table=WWW\_com It is therefore possible to use an entirely new user interface with the back end 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









