DNS over IPv6

Geoff Huston & George Michaelson
APNIC Labs
October 2012

What are the questions?

1. What proportion of DNS resolvers are capable of performing DNS queries using IPv6?

2. What proportion of users are using IPv6-capable DNS resolvers?

3. Can we see evidence of IPv6 UDP PTMU issues when we construct large responses with DNSSEC?

Experimental Technique

- Use the Ad Network!
  - It's quick – it takes a day or less to set up an ad
  - It's effective – we can perform millions of tests across the entire Internet within a few days
  - It's amazingly cheap – no user click = no payment!

The Experiment

- Set up a subdomain that only has IPv6 NS records
  - Isolate the IPv6-only subdomain server on a dedicated DNS authoritative nameserver
- Embed the unique id generation and the URL fetches in the ad control section of a Flash Object
- Enroll an online advertisement network to display the ad
- The underlying code and the retrieval of the image is executed as part of the ad display function
  - No user click-through is required (or wanted!)

Experiment Run

21 – 27 September 2012:

2,299,647 experiments were executed

432,642 experiments queried the DNS over IPv6

IPv6 DNS Resolvers

- How many DNS resolvers queried for experiment domains in dotnxdomain.net?

- How many of these DNS resolvers also queried using IPv6 for *.t7.dotnxdomain.net?

IPv6 DNS Resolvers

- How many DNS resolvers queried for experiment domains in dotnxdomain.net?

  111,538

- How many of these DNS resolvers also queried using IPv6 for *.t7.dotnxdomain.net?

  5,225

Q1: What proportion of DNS resolvers are IPv6 capable?

4.6% of visible DNS resolvers appear to be performing DNS queries using IPv6

Q1: What proportion of DNS resolvers are IPv6 capable?

4.6% of visible DNS resolvers appear to be performing DNS queries using IPv6

For comparison, 2.1% of visible DNS resolvers appear to be DNSSEC-validating resolvers, so this is not that bad a result!

Where are these IPv6-capable DNS resolvers?

CC	%v6	V6 Clients	V4 Clients	Country
BT	124%	158	127	Bhutan (*)
JE	95%	57	60	Jersey
LI	79%	43	54	Liechtenstein
HU	66%	16,717	24,969	Hungary
EE	56%	1,343	2,380	Estonia
SI	56%	3,819	6,771	Slovenia
LV	54%	1,687	3,120	Latvia
TH	49%	100,694	201,883	Thailand
FO	47%	19	40	Faroe Islands
CZ	45%	4,429	9,740	Czech Republic
PT	42%	8,776	20,576	Portugal
DE	40%	14,202	34,950	Germany
US	40%	465,169	1,145,319	United States of America (**)
ZM	39%	265	676	Zambia
UG	36%	1,353	3,749	Uganda
LU	33%	909	2,705	Luxembourg
SE	31%	3,614	11,368	Sweden
HR	30%	7,878	25,490	Croatia
ID	28%	16,219	56,762	Indonesia
JP	27%	55,314	198,785	Japan

* Some of the V4 resolvers are announced from an AS registered to a different CC code

** AS15169 (Google's global Public DNS service) is included in the US figures

The Biggest IPv6 Resolvers by Origin AS

V6 Clients	V4 Clients	AS	AS NAME
383,742	324,968	AS15169	GOOGLE - Google Inc., USA
63,344	51,998	AS45758	TRIPLETNET-AS-AP TripleT Internet, Thailand
38,954	91,186	AS7922	COMCAST-7922 - Comcast Cable Communications, Inc., USA
34,072	58,877	AS9737	TOTNET-TH-AS-AP TOT Public Company Limited, Thailand
21,453	51,389	AS4713	OCN NTT Communications Corporation, Japan
16,308	14,337	AS8708	RDSNET RCS & RDS S.A., Romania
15,746	12,609	AS2518	BIGLOBE NEC BIGLOBE, Ltd., Japan
15,415	20,048	AS12322	PROXAD Free SAS, France
13,824	13,062	AS5483	HTC-AS Magyar Telekom plc., Hungary
11,850	27,322	AS17974	PT Telekomunikasi Indonesia, Indonesia
9,736	12,105	AS3320	DTAG Deutsche Telekom AG, Germany
9,351	36,386	AS36692	OPENDNS - OpenDNS, LLC, USA
7,629	8,576	AS22773	ASN-CXA-ALL-CCI-22773-RDC - Cox Communications Inc., USA
7,443	5,412	AS7018	ATT-INTERNET4 - AT&T Services, Inc., USA
7,435	8,527	AS3243	TELEPAC PT Comunicacoes, S.A.,Portugal
6,054	962	AS6939	HURRICANE - Hurricane Electric, Inc., USA
5,826	14,064	AS5391	T-HT Hrvatski Telekom d.d., Croatia
4,922	6,273	AS6327	SHAW - Shaw Communications Inc., Canada
4,584	4,610	AS10030	CELCOMNET-AP Celcom Internet Service Provider, Malaysia
4,549	5,810	AS9824	ASN-ATHOMEJP Technology Networks Inc., Japan

Now lets look at Clients:

- How many experiments completed DNS queries?

- How many experiments completed IPv6 DNS queries?

Q2: What proportion of users are using IPv6-capable DNS resolvers?

- How many experiments completed DNS queries?

  2,300,384

- How many experiments completed IPv6 DNS queries?

  432,632 or **19%**

Still looking at Clients:

- How many unique IP addresses completed web fetches for objects named in the experiment?

- How many clients were able to perform web fetches that required IPv6 DNS resolvers?

Still looking at Clients:

- How many unique IP addresses completed web fetches for objects named in the experiment?

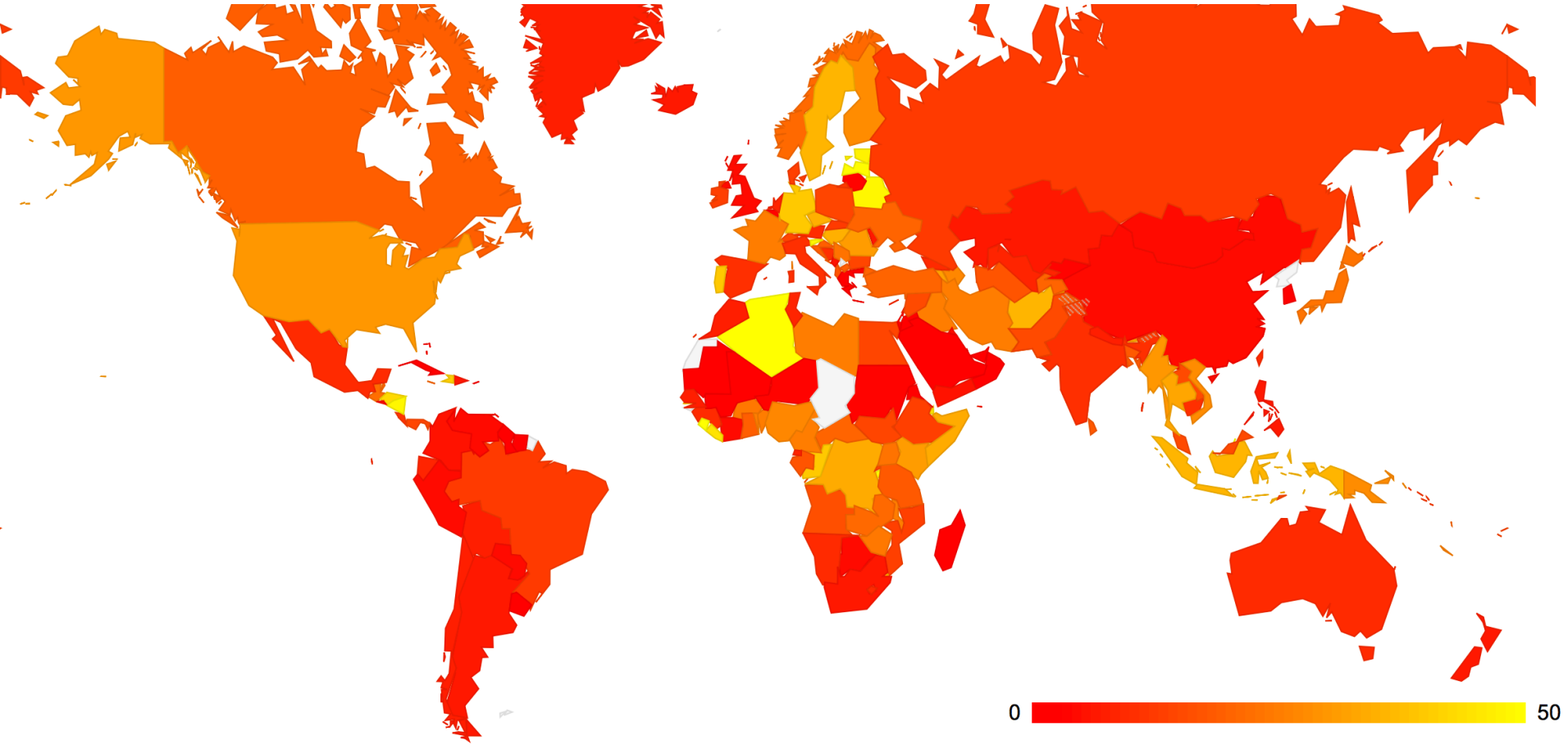
  890,920

- How many clients were able to perform web fetches that required IPv6 DNS resolvers?

  161,125 or 18%

Where can we find clients who have IPv6-capable DNS resolvers?

Where can we find clients who have IPv6-capable DNS resolvers?



Client use of DNS over IPv6 by country (%)
September 2012

The top of the country list

% who IPv6 DNS	Clients who V6 DNS	All clients	
100.00%	1	1	Nauru
90.00%	9	10	Burundi
87.10%	27	31	Saint Vincent and the Grenadines
84.62%	11	13	Saint Pierre and Miquelon
84.00%	21	25	Jersey
80.00%	4	5	Guadeloupe
68.42%	13	19	Liechtenstein
63.64%	14	22	Faroe Islands
62.76%	246	392	Brunei Darussalam
54.55%	6	11	Sierra Leone
52.08%	676	1,298	Occupied Palestinian Territory
50.44%	1,710	3,390	Algeria
49.54%	590	1,191	Latvia
48.90%	1,540	3,149	Belarus
48.88%	1,048	2,144	Slovenia
48.27%	167	346	Nicaragua
47.29%	514	1,087	Estonia
44.72%	89	199	Djibouti
44.44%	4	9	Liberia
42.72%	132	309	Honduras
40.98%	50	122	Haiti
40.00%	4	10	Congo
39.36%	3,520	8,943	Germany
39.14%	2,591	6,619	Portugal
38.24%	13	34	Gambia

The top of the country list

% who IPv6 DNS	Clients who V6 DNS	All clients	
52.08%	676	1,298	Occupied Palestinian Territory
50.44%	1,710	3,390	Algeria
49.54%	590	1,191	Latvia
48.90%	1,540	3,149	Belarus
48.88%	1,048	2,144	Slovenia
47.29%	514	1,087	Estonia
39.36%	3,520	8,943	Germany
39.14%	2,591	6,619	Portugal
36.15%	1,486	4,111	Singapore
36.12%	7,769	21,509	Indonesia
35.70%	623	1,745	Sweden
35.05%	184	525	Luxembourg
34.52%	1,240	3,592	Czech Republic
34.38%	3,342	9,721	Hungary
32.89%	11,232	34,152	Thailand
31.34%	874	2,789	Armenia
31.08%	5,748	18,497	Romania
31.07%	933	3,003	Kenya
30.06%	11,006	36,616	USA
27.58%	1,710	6,201	Vietnam
27.46%	299	1,089	Finland
26.90%	202	751	Nigeria
26.87%	632	2,352	Azerbaijan
25.07%	285	1,137	Iraq
25.02%	3,697	14,778	France

Ranking only those CCs with more than 500 sample points in this experiment run (111 CC's)

The bottom of the country list

% who IPv6 DNS	Clients who V6 DNS	All clients	
52.08%	676	1,298	Occupied Palestinian
50.44%	1,710	3,390	Algeria
49.54%	590	1,191	Latvia
48.90%	1,540	3,149	Belarus
48.88%	1,048	2,144	Slovenia
47.29%	514	1,087	Estonia
39.36%	3,520	8,943	Germany
39.14%	2,591	6,619	Portugal
36.15%	1,486	4,111	Singapore
36.12%	7,769	21,509	Indonesia
35.70%	623	1,745	Sweden
35.05%	184	525	Luxembourg
34.52%	1,240	3,592	Czech Republic
34.38%	3,342	9,721	Hungary
32.89%	11,232	34,152	Thailand
31.34%	874	2,789	Armenia
31.08%	5,748	18,497	Romania
31.07%	933	3,003	Kenya
30.06%	11,006	36,616	USA
27.58%	1,710	6,201	Vietnam
27.46%	299	1,089	Finland
26.90%	202	751	Nigeria
26.87%	632	2,352	Azerbaijan
25.07%	285	1,137	Iraq
25.02%	3,697	14,778	France

% who IPv6 DNS	Clients who V6 DNS	All clients	
0.87%	624	72,039	Republic of Korea
1.00%	103	10,306	Qatar
1.27%	205	16,203	United Arab Emirates
1.28%	18	1,404	Uruguay
1.40%	28	2,003	Malta
1.43%	9	630	Mali
2.09%	33	1,580	Puerto Rico
2.21%	48	2,171	Bahrain
2.38%	30	1,259	Mauritius
2.55%	70	2,745	Oman
2.62%	558	21,334	Saudi Arabia
2.70%	842	31,199	Greece
2.71%	44	1,624	Macao
2.72%	66	2,429	Jordan
2.84%	20	703	Sudan
2.84%	137	4,817	Belgium
3.05%	108	3,542	Israel
3.45%	218	6,311	Lithuania
3.91%	3,222	82,391	China
3.94%	150	3,804	Venezuela
3.99%	30	752	El Salvador
4.25%	27	635	Trinidad and Tobago
4.37%	38	870	Paraguay
4.56%	985	21,618	United Kingdom
4.59%	300	6,534	Peru

Ranking only those CCs with more than 500 sample points in this experiment run (111 CC's)

Clients who have IPv6-capable DNS resolvers by AS - the top AS's

% who IPv6 DNS		Clients who V6 DNS	All clients	
89%	AS52242	50	56	Yota De Nicaragua, Nicaragua
89%	AS15169	147	165	GOOGLE - Google Inc., United States of America
88%	AS28545	52	59	Cablemas Telecomunicaciones SA de CV, Mexico
88%	AS28220	78	89	, Brazil
87%	AS28509	95	109	Cablemas Telecomunicaciones SA de CV, Mexico
86%	AS38844	51	59	NTNU-TW National Taiwan Normal University, Taiwan
86%	AS28516	72	84	Cablemas Telecomunicaciones SA de CV, Mexico
85%	AS36991	53	62	ORANGE-UG, Uganda
85%	AS42248	52	61	VIDA-OPTICS Vida Optics TVV, Bulgaria
85%	AS28512	46	54	Cablemas Telecomunicaciones SA de CV, Mexico
85%	AS53006	252	296	, Brazil
85%	AS262227	106	125	Claro Panam· S.A., Panama
84%	AS21804	54	64	ACCESS-SK - Access Communications Co-operative Limited, Canada
84%	AS39309	54	64	EDUTEL-AS Edutel B.V., Netherlands
83%	AS11814	278	333	DISTRIBUTEL-AS11814 - DISTRIBUTEL COMMUNICATIONS LTD., Canada
83%	AS7922	5,743	6,902	COMCAST-7922 - Comcast Cable Communications, Inc., United States of America
83%	AS3243	2,385	2,872	TELEPAC PT Comunicacoes, S.A., Portugal
83%	AS52075	62	75	WIFIRST Wifirst S.A.S., France
82%	AS15975	497	609	HADARA-AS Hadara Technologies, Occupied Palestinian Territory
82%	AS198471	71	87	LINKEM-AS Linkem spa, Italy
82%	AS35063	62	76	TKCHOPIN-AS TKChopin Computer Centre, Poland
81%	AS5645	365	448	TEKSAVVY-TOR TekSavvy Solutions Inc. Toronto, Canada
81%	AS25441	82	101	IBIS-AS Imagine Group Ltd., Ireland
81%	AS29084	182	225	COMNET-AS Comnet Bulgaria Holding Ltd., Bulgaria
80%	AS49363	275	343	OAR-DC "Orange Armenia" CJSC, Armenia
80%	AS42689	56	70	CABLECOM-AS Cablecom Networking Limited, United Kingdom

Ranking only those ASs with more than 50 sample points in this experiment run (1,194 AS's)

Q3: Can we see evidence of IPv6 UDP PTMU issues when we construct large responses with DNSSEC?

Q3: Can we see evidence of IPv6 UDP PTMU issues when we construct large responses with DNSSEC?

No!

We run Bind 9.9.1 on FreeBSD

which sets the V6 UDP socket to the min MTU

so we don't see any UDP response fragmentation

(draft-andrews-dnsext-udp-fragmentation-01.txt)

Can we see evidence of other IPv6 PTMU issues?

Yes, in DNS over TCP over IPv6

We used a local MTU of 1500

And we received 4,670 ICMP packet too big ICMP messages:

4 messages proposed 1280 octet MTU

19 messages proposed 1476

265 messages proposed 1480

4,382 messages proposed 1500 ?

Broken IPv6 MTU routers

Who is sending these broken 1500 octet ICMP6 PTB messages?

#msgs	router	CC	AS	AS Name
62	2001:620:610:20::20	CH	AS559,	Swiss Education and Research Network
12	2001:630:0:9003::2	GB	AS786,	JANET The JNT Association
4	2001:630:53:89c4::26	GB	AS786,	JANET The JNT Association
8	2001:660:3305:a205::111	FR	AS2200,	Reseau National de telecommunications pour la Technologie
2	2001:6a8:2500:1000::2	BE	AS2611,	BELNET
73	2001:c18:0:3001::4	MY	AS10204,	ARCNET-NTT
102	2001:c38:9004:6::2	BE	AS2611,	Communication Authority of Thailand
3649	2001:c68:bfff:5::d	CN	AS4134,	CHINANET-BACKBONE
69	2001:ff8:1:254::24	MO	AS7582,	University of Macau
26	2001:1284:ff00:ffff::4	BR	AS14868,	Companhia Paranaense de Energia - COPEL
10	2001:14f0:0:5::e	DE	AS12355,	HHeLi NET Telekommunikation GmbH & Co. KG
10	2001:49b8::a	US	AS21737,	SPRINGNET2-NET - SpringNet
55	2401:b000:2::a	MY	AS17971,	TMVADS-AP TM-VADS DC Hosting
294	2605:f000::3	US	AS22442,	PHONOSCOPE
6	2a00:dc8:0:f::4	NL	AS39637,	Netlogics BV

The Good, and the not-so-Good

☺ 18% of today's clients appear use DNS resolvers that are capable of undertaking DNS queries for domains whose authoritative nameservers are IPv6-only

☹ But only some 0.18% of today's clients will use IPv6 to actually fetch a dual stack object

Thank you!