Measuring DNSSEC Use

Geoff Huston
APNIC

Some Questions…

- Who is using DNSSEC validation?
- What is the DNSSEC performance overhead for users and servers?
- What happens when the DNSSEC signature is not valid?

And a Measurement Technique

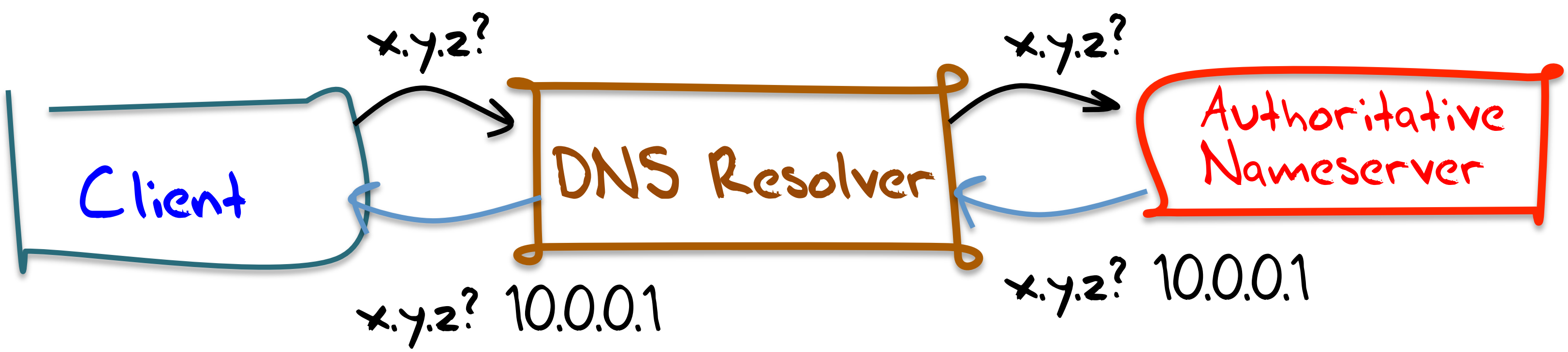
Three URLs:

- the good (DNSSEC signed)
- the bad (invalid DNSSEC signature)
- the control (no DNSSEC at all)

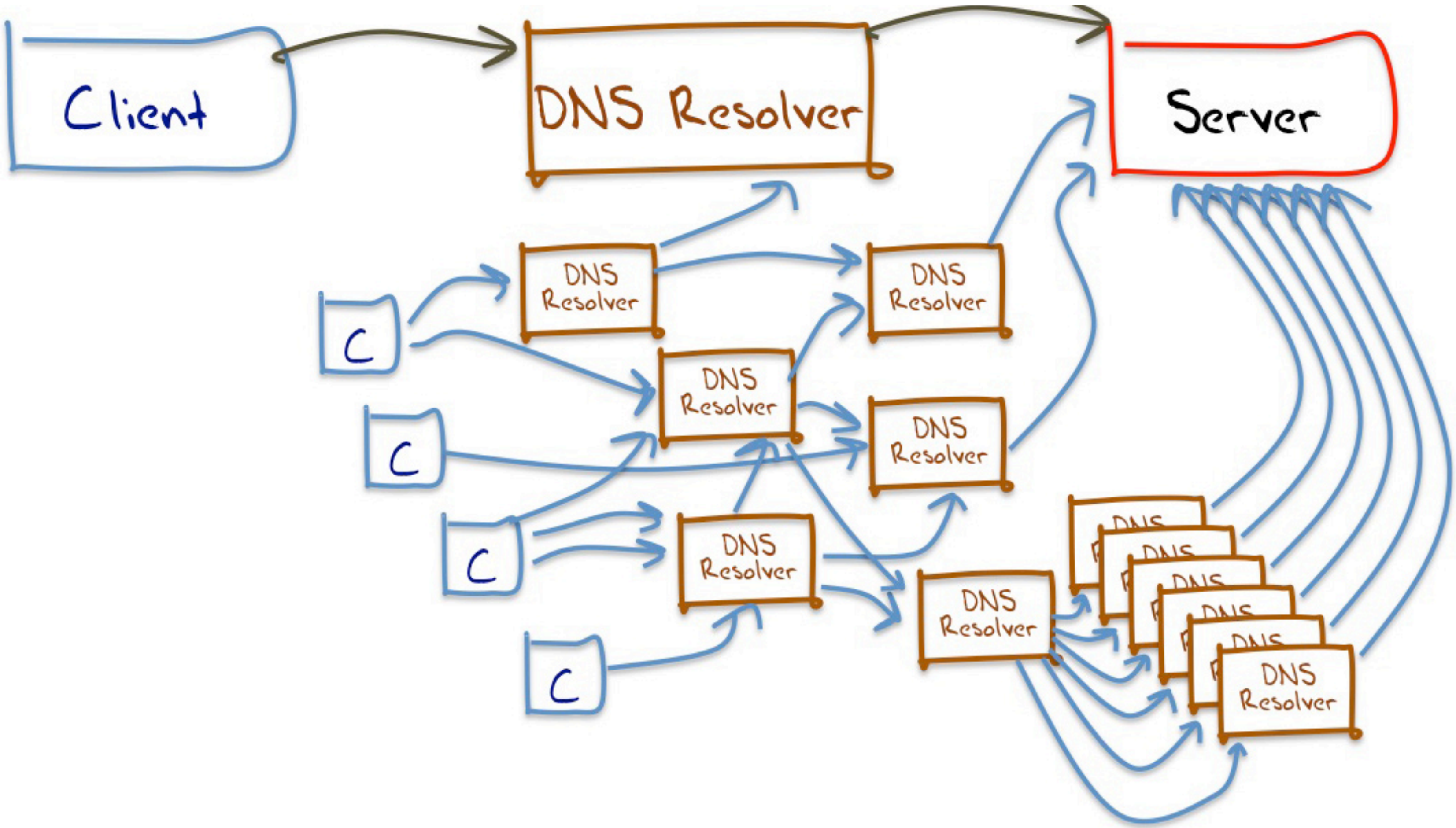
And an online ad system to deliver the test to a large set of clients drawn from all over the Internet

Understanding Resolvers is "tricky"

What we would like to think happens in DNS resolution!

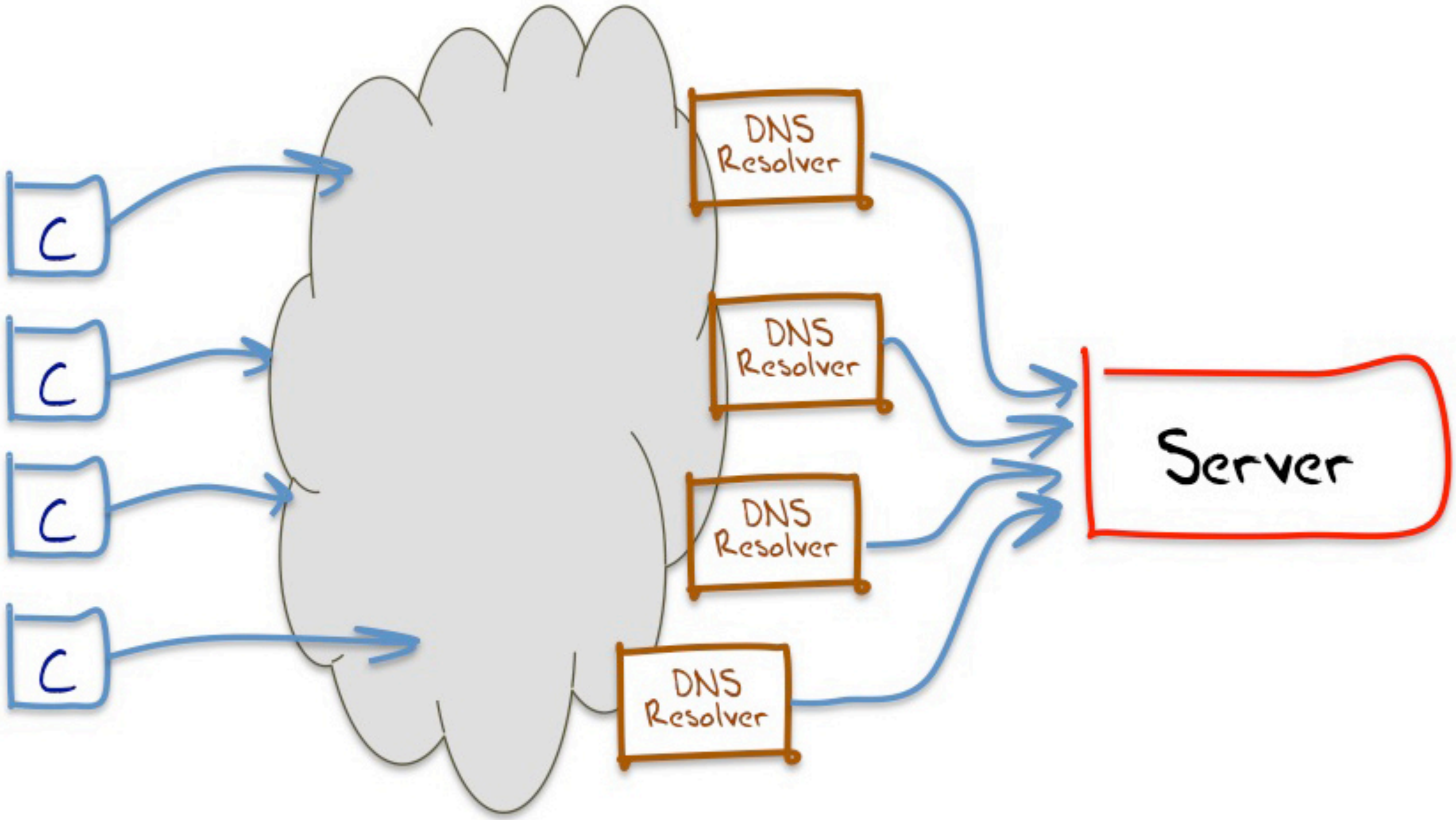


Understanding Resolvers is "tricky"



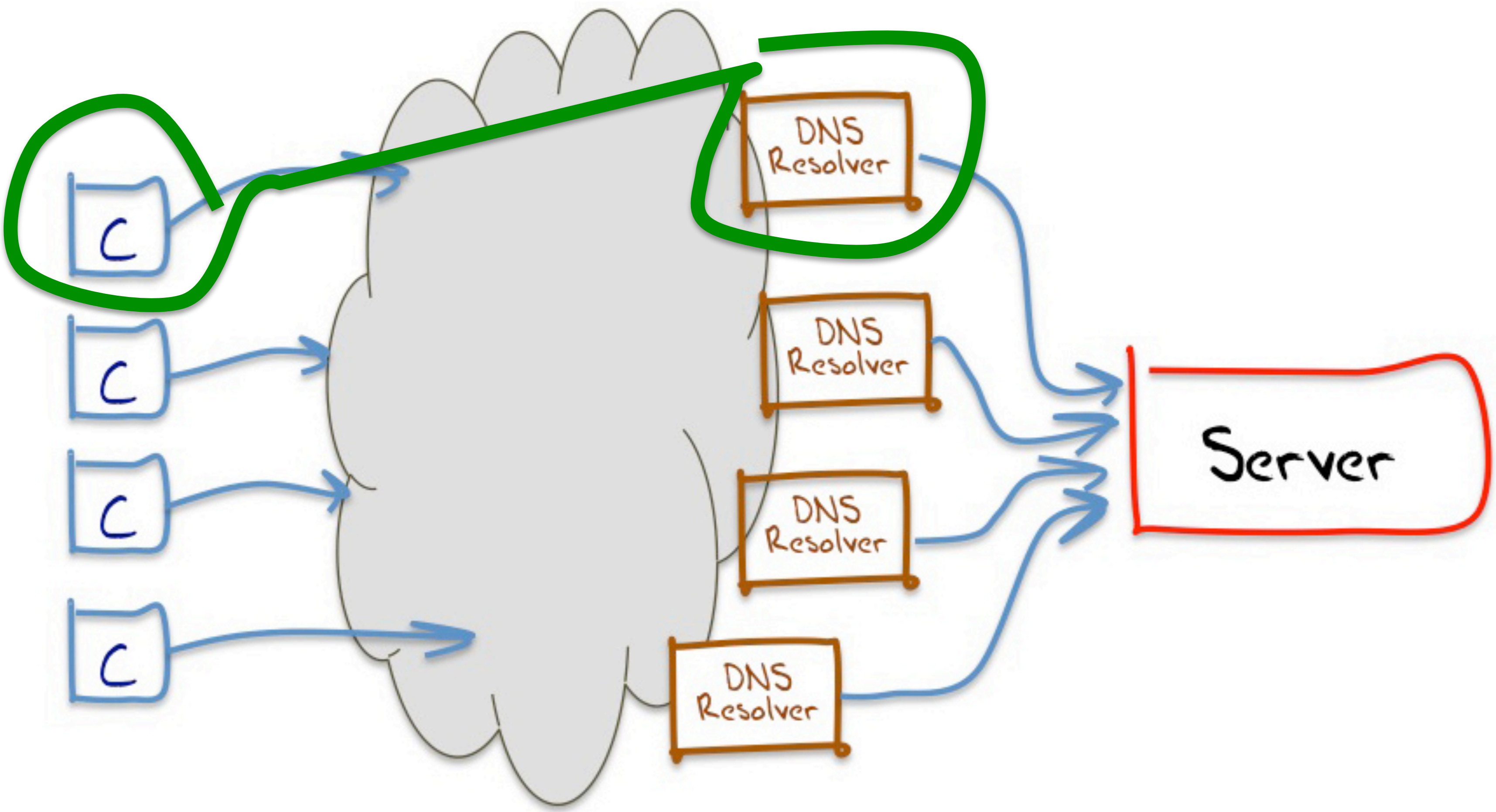
A small sample of what appears to happen in DNS resolution

Understanding Resolvers is "tricky"



The best model we can use for DNS resolution

Understanding Resolvers is "tricky"



if we combine www and dns data we can map clients to the visible resolvers that query our server

This means…

That it is hard to talk about "all resolvers"

- We don't know how many resolvers we can see from the perspective of an authoritative name server
- We can only talk about "visible resolvers"

And there is an added issue with DNSSEC:

- It can be hard to tell the difference between a visible resolver performing DNSSEC validation and a hidden validating resolver performing validation via a visible non-validating forwarder

So it's easier to talk about end clients, and whether we see end-clients use / don't use a DNS resolution service that performs DNSSEC validation

Some Results

Web + DNS query log processing

9 – 26 May 2013

Completed Test Count: 2,498,497

- Clients who use visible resolvers that appear to perform DNSSEC Validation: **8.3%**
- Clients who use visible resolvers that appear to use a mix of resolvers: **4.3%**
- Clients whose visible resolvers did not have a DNSSEC clue, and only fetched A, AAAA RRs**: 87.4%**

Where is DNSSEC? - The Top 20

Rank	CC	Count	% D	% x	% A	Country
[illegible]	[illegible]	[illegible]	77.92	3.38	18.70	Sweden
[illegible]	[illegible]	[illegible]	[illegible].85	4.90	36.25	Slovenia
[illegible]	[illegible]	[illegible]	[illegible]3.87	6.[illegible]0	49.23	[illegible]uxembourg
[illegible]	[illegible]	[illegible]	38.28	4.[illegible]	57.69	[illegible]nam
[illegible]	[illegible]	[illegible]	37.01	16.[illegible]	46.70	[illegible]
[illegible]	[illegible]	[illegible]	33.20	8.[illegible]	58.72	[illegible]
[illegible]	[illegible]	[illegible]	30.26	8.[illegible]	61.41	[illegible]
[illegible]	[illegible]	[illegible]	28.22	3.[illegible]	68.67	[illegible]
9	IE	8,079	[illegible]	[illegible]	68.96	[illegible]
10	BB	1,312	[illegible]	[illegible]	[illegible]24	[illegible]
11	ID	54,816	[illegible]	[illegible]	[illegible]55	Indonesia
12	UA	26,399	[illegible]	[illegible]	[illegible]60	Ukraine
13	ZA	2,969	[illegible]	[illegible]	[illegible]48	South Africa
14	TR	49,498	[illegible]	[illegible]	[illegible]84	Turkey
15	US	140,234	[illegible]	[illegible]	[illegible]11	United States of America
16	EG	36,061	[illegible]	[illegible]	[illegible]01	Egypt
17	GH	973	[illegible]	[illegible]	[illegible]29	Ghana
18	AZ	7,409	14.55	30.34	55.11	Azerbaijan
19	BR	179,424	14.43	6.13	79.44	Brazil
20	PS	2,893	14.00	36.85	49.15	Occupied Palestinian Territory

% of clients who appear to use DNSSEC-validating resolvers

% of clients who use a mix of DNSSEC-validating resolvers and non-validating resolvers

% of clients who use non-validating resolvers

When we geo-locate clients to countries, what proportion of these clients: perform DNSSEC validation? Retrieve some DNSSEC RRs? Do not retrieve any DNSSEC RRs?

Where is DNSSEC? - The Top 20

Rank	CC	Count	% D	% x	% A	Country
1	SE	5,349	77.92	3.38	18.70	Sweden
2	SI	4,758	58.85	4.90	36.25	Slovenia
3	LU	652	43.87	6.90	49.23	Luxembourg
4	VN	26,665	38.28	4.04	57.69	Vietnam
5	FI	2,456	37.01	16.29	46.70	Finland
6	CZ	30,827	33.20	8.08	58.72	Czech Republic
7	CL	46,151	30.26	8.34	61.41	Chile
8	JM	1,545	28.22	3.11	68.67	Jamaica
9	IE	8,079	27.94	3.11	68.96	Ireland
10	BB	1,312	24.24	1.52	74.24	Barbados
11	ID	54,816	23.87	8.58	67.55	Indonesia
12	UA	26,399	21.65	12.75	65.60	Ukraine
13	ZA	2,969	21.15	9.36	69.48	South Africa
14	TR	49,498	18.06	2.10	79.84	Turkey
15	US	140,234	17.32	3.57	79.11	United States of America
16	EG	36,061	14.68	10.32	75.01	Egypt
17	GH	973	14.59	8.12	77.29	Ghana
18	AZ	7,409	14.55	30.34	55.11	Azerbaijan
19	BR	179,424	14.43	6.13	79.44	Brazil
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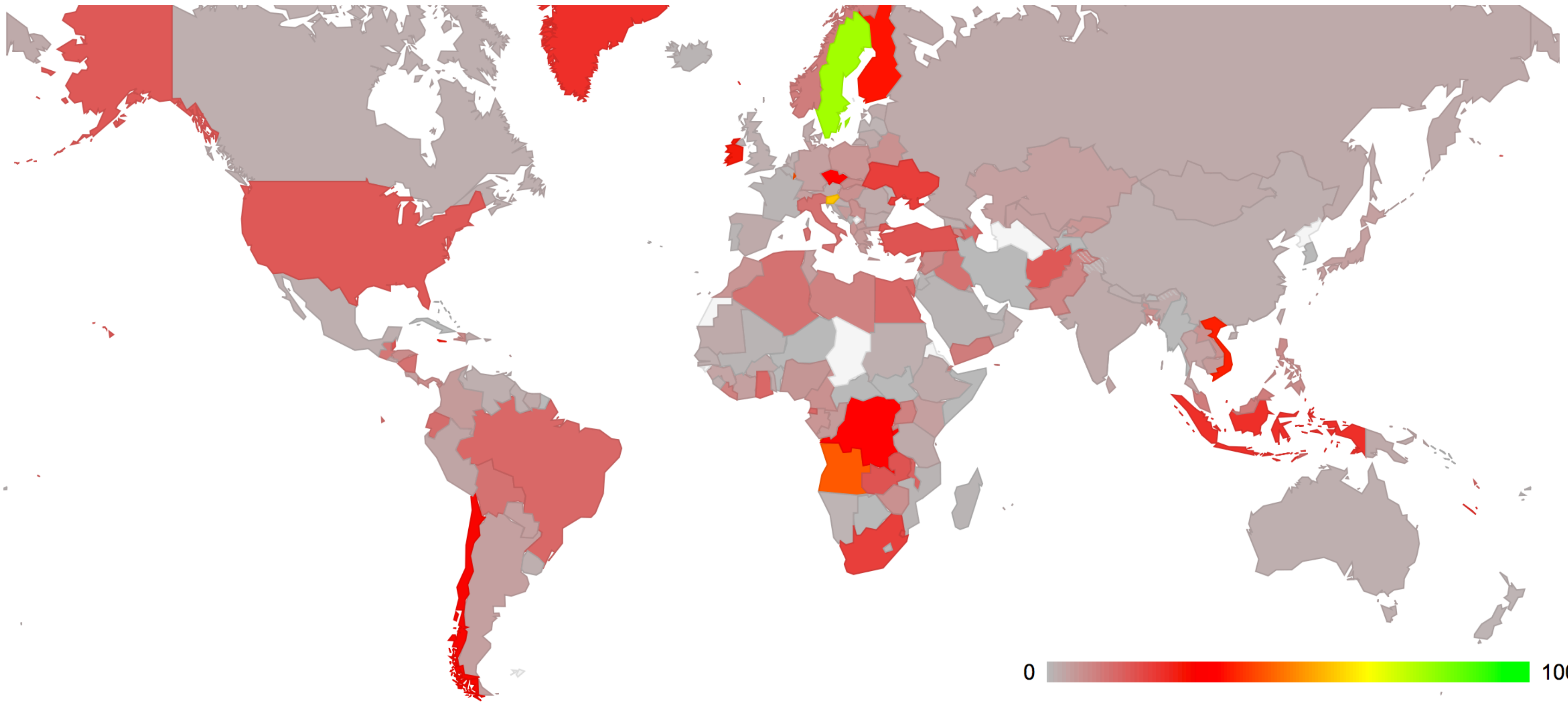
The Map View



% of clients who perform DNSSEC validation

Is Google's P-DNS a Factor?

Google Online Security Blog
The latest news and insights from Google
on security and safety on the Internet

Google Public DNS Now Supports DNSSEC Validation

Tuesday, March 19, 2013 8:30 AM
Posted by Yunhong Gu, Team Lead, Google Public DNS

We launched Google Public DNS three years ago to help make the Internet faster and more secure. Today, we are taking a major step towards this security goal: we now fully support DNSSEC (Domain Name System Security Extensions) validation on our Google Public DNS resolvers. Previously, we accepted and forwarded DNSSEC-formatted messages but did not perform validation. With this new security feature, we can better protect people from DNS-based attacks and make DNS more secure overall by identifying and rejecting invalid responses from DNSSEC-protected domains.

DNS translates human-readable domain names into IP addresses so that they are accessible by computers. Despite its critical role in Internet applications, the lack of security protection for DNS up to this point meant that a significantly large portion of today's Internet attacks target the name resolution process, attempting to return the IP addresses of malicious websites to DNS queries. Probably the most common DNS attack is DNS cache poisoning, which tries to "pollute" the cache of DNS resolvers (such as Google Public DNS or those provided by most ISPs) by injecting spoofed responses to upstream DNS queries.

Is Google's P-DNS a Factor?

- Clients who used Google's Public DNS servers to resolve names: **7.2%**
  - Exclusively Used Google's P-DNS: 5.3%
  - Used a mix of Google P-DNS + others: 1.9%
- Clients who used other resolvers: **92.8%**

Is Google's P-DNS a Factor?

Rank	CC	Count	% D		%AG	%SG	%NG	Country
1	SE	5,34	[illegible]	[illegible]	1.78	0.19	98.03	Sweden
2	SI	4,75	[illegible]	[illegible]	.89	0.2	91.89	Slovenia
3	LU	65	[illegible]	[illegible]	1.40	0.0	98.60	uxembourg
4	VN	26,66	[illegible]	[illegible]	96.66	2.2	1.09	am
5	FI	2,45	[illegible]	[illegible]	2.64	0.3	97.03	[illegible]
6	CZ	30,82	[illegible]	[illegible]	11.71	3.9	84.30	[illegible]
7	CL	46,15	[illegible]	[illegible]	3.62	0.4	95.92	[illegible]
8	JM	1,54	[illegible]	[illegible]	91.74	0.6	7.57	[illegible]
9	IE	8,079	27.94	->	12.18	0.9	86.89	[illegible]
10	BB	1,312	24.24	->	[illegible]	[illegible]	82	[illegible]
11	ID	54,816	23.87	->	[illegible]	[illegible]	01	Indonesia
12	UA	26,399	21.65	->	[illegible]	[illegible]	01	Ukraine
13	ZA	2,969	21.15	->	[illegible]	[illegible]	47	South Africa
14	TR	49,498	18.06	->	[illegible]	[illegible]	41	Turkey
15	US	140,234	17.32	->	[illegible]	[illegible]	98	United States of America
16	EG	36,061	14.68	->	[illegible]	[illegible]	84	Egypt
17	GH	973	14.59	->	59.86	14.08	26.06	Ghana
18	AZ	7,409	14.55	->	71.24	26.72	2.04	Azerbaijan
19	BR	179,424	14.43	->	50.31	7.08	42.61	Brazil
20	PS	2,893	14.00	->	40.49	59.51	0.00	Occupied Palestinian Terr.

% of validating clients who exclusively use Google's P-DNS

% of clients who use a mix of Google's P-DNS and other resolvers

% of clients who do not use Google's P-DNS service

Of those clients who perform DNSSEC validation, what resolvers are they using: All Google P-DNS, Some Google P-DNS? No Google P-DNS?

Is Google's P-DNS a Factor?

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4	VN	26,665	38.28	->	96.66	2.25	1.09	Vietnam
5	FI	2,456	37.01	->	2.64	0.33	97.03	Finland
6	CZ	30,827	33.20	->	11.71	3.99	84.30	Czech Republic
7	CL	46,151	30.26	->	3.62	0.45	95.92	Chile
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10	BB	1,312	24.24	->	7.86	0.31	91.82	Barbados
11	ID	54,816	23.87	->	68.36	12.63	19.01	Indonesia
12	UA	26,399	21.65	->	19.84	2.15	78.01	Ukraine
13	ZA	2,969	21.15	->	5.73	0.80	93.47	South Africa
14	TR	49,498	18.06	->	93.25	3.33	3.41	Turkey
15	US	140,234	17.32	->	7.28	0.73	91.98	United States of America
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Of those clients who perform DNSSEC validation, what resolvers are they using: All Google P-DNS, Some Google P-DNS? No Google P-DNS?

DNSSEC by Networks – the Top 25

Rank	AS	Count	% D	%x	%A	%G	AS Name
1	[illegible]	[illegible]	98.73	0.14	1.13	0.71	Com Hem, SE
2	[illegible]	[illegible]	[illegible]	[illegible]	0.00	0.49	[illegible]
3	[illegible]	[illegible]	97.71	[illegible]	[illegible]	2.34	[illegible]
4	[illegible]	[illegible]	96.76	[illegible]	2.40	1.24	[illegible]
5	[illegible]	[illegible]	96.74	[illegible]	2.41	1.07	[illegible]
6	[illegible]	[illegible]	96.72	[illegible]	2.41	0.53	[illegible]
7	[illegible]	[illegible]	96.44	[illegible]	2.47	99.86	[illegible]
8	[illegible]	[illegible]	96.05	[illegible]	3.26	[illegible]	[illegible]
9	AS5466	2,093	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	AS6849	4,596	[illegible]	[illegible]	[illegible]	[illegible]	UKRTELECOM, UA
11	AS3301	1,445	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	AS5610	6,889	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	AS7922	24,129	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	AS22047	15,274	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	AS1257	795	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	AS38511	1,221	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	AS2519	523	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	AS1759	562	51.78	26.51	21.71	2.06	TeliaSonera, FI
19	AS2819	734	48.37	15.53	36.10	20.85	GTSCZ GTS Czech, CZ
20	AS45899	14,306	45.93	3.16	50.91	97.76	VNPT, VN
21	AS27738	950	45.79	40.11	14.11	4.60	Ecuadortelecom, EC
22	AS12301	6,885	42.96	3.59	53.45	5.71	Invitel Tavkozlesi HU
23	AS4230	1,327	37.91	17.48	44.61	59.44	EMBRATEL-EMPRESA, BR
24	AS34170	1,169	36.36	55.18	8.47	72.00	AZTELEKOM Azerbaijan Tele, AZ
25	AS7552	3,708	35.92	5.02	59.06	96.47	Vietel, VN

% of clients who appear to use DNSSEC-validating resolvers

% of clients who use a mix of DNSSEC-validating resolvers and non-validating resolvers

% of clients who use non-validating resolvers

% of validating clients who exclusively use Google's P-DNS

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Rank	AS	Count	% D	%x	%A	%G	AS Name
1	AS39651	710	98.73	0.14	1.13	0.71	Com Hem, SE
2	AS27831	627	97.77	2.23	0.00	0.49	Colombia Movil,CO
3	AS12912	1,486	97.71	1.14	1.14	2.34	ERA Polska Telefonia, PL
4	AS34779	834	96.76	0.84	2.40	1.24	T-2 Slovenia, SI
5	AS29562	582	96.74	0.86	2.41	1.07	Kabel BW GmbH, DE
6	AS5603	1,372	96.72	0.87	2.41	0.53	Telekom Slovenije, SI
7	AS198471	730	96.44	1.10	2.47	99.86	Linkem spa, IT
8	AS719	583	96.05	0.69	3.26	1.07	Elisa Oyj, EU
9	AS5466	2,093	94.70	1.53	3.77	1.21	Eircom, IE
10	AS6849	4,596	92.43	2.15	5.42	3.55	UKRTELECOM, UA
11	AS3301	1,445	91.56	1.45	6.99	1.44	TeliaSonera, SE
12	AS5610	6,889	90.58	2.48	6.94	4.97	TO2 Telefonica Czech Rep., CZ
13	AS7922	24,129	89.57	2.07	8.36	1.09	Comcast Cable, US
14	AS22047	15,274	88.61	9.68	1.71	1.12	VTR BANDA ANCHA, CL
15	AS1257	795	86.29	1.38	12.33	1.60	TELE2, SE
16	AS38511	1,221	79.36	4.18	16.46	10.84	PT Remala Abadi, ID
17	AS2519	523	57.36	3.82	38.81	0.67	VECTANT, JP
18	AS1759	562	51.78	26.51	21.71	2.06	TeliaSonera, FI
19	AS2819	734	48.37	15.53	36.10	20.85	GTSCZ GTS Czech, CZ
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Aside: Google's Public DNS

Aside: Google's Public DNS in May 2013

	All-Google	Mixed-Google	No-Google
May-13	5.3%	1.9%	92.8%

But then something changed

	All-Google	Mixed-Google	No-Google
May-13	5.3%	1.9%	92.8%

June 2013


Edward Snowden

From Wikipedia, the free encyclopedia

Further information: 2013 mass surveillance disclosures

Edward Joseph "Ed"[2][3] **Snowden** (born June 21, 1983) is an American computer specialist and a former CIA and NSA employee who intentionally disclosed classified details of several top-secret United States and British government mass surveillance programs to the press.[4][5]

Based on information Snowden leaked to *The Guardian*[6] in May 2013 while employed at NSA contractor Booz Allen Hamilton, the British newspaper published a series of exposés that revealed programs such as the interception of U.S. and European telephone metadata and the PRISM, XKeyscore, and Tempora Internet surveillance programs. Snowden's release of NSA material was called the most significant leak in U.S. history by Pentagon Papers leaker Daniel Ellsberg.[7][8][9]

In June 2013, US federal prosecutors charged Snowden with espionage and theft of government property.[10][11][12] Snowden fled the United States prior to the publication of his disclosures, first to Hong Kong (China) and then on to Moscow (Russia), where he was granted political asylum within Russian borders by the government of Russia at the end of July 2013 and where he now resides at an undisclosed location.

Snowden has been a subject of controversy: he has been variously called a hero,[13][14] a whistleblower,[15][16][17][18] a dissident,[19] a traitor,[20][21] and a patriot.[22][23] There is confusion on exactly what Snowden's status is, and whether he truly qualifies as a whistleblower, which commonly is understood as a person who exposes wrongdoing. By avoiding labeling Snowden a whistleblower, some members of the media attempt to avoid making a value judgement on his actions. Tom Kent, the standards editor for the Associated Press, informed AP staff to refer to Snowden as a "leaker", not a "whistleblower".[24] But David K. Colapinto of the National Whistleblower Center said in June 2013 that

http://en.wikipedia.org/wiki/Edward_Snowden

And Afterwards?

	All-Google	Mixed-Google	No-Google
May-13	5.3%	1.9%	92.8%
Jul-13	4.6%	2.1%	93.4%
Aug-13	4.4%	2.1%	93.5%
Sep-13	4.7%	2.1%	93.2%

June 2013

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From Wikipedia, the free encyclopedia

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Who Used Google's Public DNS in September?

Rank	CC	Count	%_All	%_Some	%_Not	DNSSEC	%_All	%_Some	%_None	Country
1	VN	9140	44.37	2.81	52.82	3573	97.90	1.60	0.50	Vietnam
2	NG	396	31.57	14.14	54.29	26	88.46	11.54	0.00	Nigeria
3	GT	945	24.44	8.47	67.09	121	64.46	14.05	21.49	Guatemala
4	AM	333	23.42	1.80	74.77	69	94.20	2.90	2.90	Armenia
5	AZ	507	21.10	22.88	56.02	95	72.63	8.42	18.95	Azerbaijan
6	BD	1623	20.09	10.35	69.56	135	68.89	24.44	6.67	Bangladesh
7	JM	566	19.96	2.65	77.39	96	95.83	4.17	0.00	Jamaica
8	HN	590	19.83	19.83	60.34	39	92.31	7.69	0.00	Honduras
9	ID	15295	18.69	5.58	75.74	2757	83.90	5.91	10.19	Indonesia
10	DZ	6966	17.73	35.59	46.68	1202	78.62	20.80	0.58	Algeria
11	IQ	982	16.90	12.12	70.98	98	45.92	33.67	20.41	Iraq
12	GH	459	16.56	12.20	71.24	33	96.97	3.03	0.00	Ghana
13	PS	789	14.83	15.59	69.58	176	46.59	31.82	21.59	Occupied Palestinian Territory
14	TZ	305	14.43	20.33	65.25	11	90.91	9.09	0.00	United Republic of Tanzania
15	TR	42456	12.91	1.83	85.26	4671	93.79	3.64	2.57	Turkey
16	MY	18190	12.13	3.02	84.85	1789	90.16	4.36	5.48	Malaysia
17	EG	11876	12.10	4.57	83.33	1161	93.20	6.46	0.34	Egypt
18	CR	522	11.30	2.30	86.40	33	90.91	9.09	0.00	Costa Rica
19	BR	34997	11.14	3.40	85.46	4323	60.33	9.14	30.53	Brazil
20	IT	28909	11.12	0.90	87.98	3609	72.10	1.52	26.38	Italy
21	UA	5808	10.88	2.74	86.38	1364	20.09	2.42	77.49	Ukraine
22	LB	651	9.37	10.29	80.34	72	38.89	27.78	33.33	Lebanon
23	CM	261	8.43	19.54	72.03	37	43.24	40.54	16.22	Cameroon
24	PA	968	8.16	1.55	90.29	68	100.00	0.00	0.00	Panama
25	AL	858	8.16	2.21	89.63	47	95.74	2.13	2.13	Albania
26	KE	817	8.08	11.14	80.78	64	60.94	25.00	14.06	Kenya
27	AR	14981	7.94	3.04	89.02	1066	75.14	10.13	14.73	Argentina
28	CZ	5099	7.92	3.43	88.64	1580	12.03	4.18	83.80	Czech Republic
29	MK	802	7.86	0.50	91.65	41	90.24	0.00	9.76	The former Yugoslav Republic of Macedonia
30	UG	324	7.72	8.64	83.64	22	77.27	22.73	0.00	Uganda
31	KZ	653	7.35	5.21	87.44	41	68.29	31.71	0.00	Kazakhstan

Who Turned Google OFF?

Rank	CC	Delta OFF	MAY%	SEP %	Country
1	NI	37.77%	56.15%	18.38%	Nicaragua
2	PS	22.73%	53.15%	30.42%	Occupied Palestinian Territory
3	BO	21.54%	33.28%	11.74%	Bolivia
4	BN	10.27%	56.10%	45.83%	Brunei Darussalam
5	KE	8.28%	27.50%	19.22%	Kenya
6	AL	6.41%	16.78%	10.37%	Albania
7	LA	6.36%	26.00%	19.64%	Lao People's Democratic Republic
8	MZ	6.33%	17.54%	11.21%	Mozambique
9	PK	6.18%	18.27%	12.09%	Pakistan
10	JM	5.34%	27.95%	22.61%	Jamaica
11	TR	5.25%	19.99%	14.74%	Turkey
12	AZ	5.17%	49.15%	43.98%	Azerbaijan
13	TZ	4.98%	39.73%	34.75%	United Republic of Tanzania
14	GT	3.54%	36.45%	32.91%	Guatemala
15	BA	3.17%	9.05%	5.88%	Bosnia and Herzegovina
16	SR	2.59%	5.09%	2.50%	Suriname
17	IT	2.38%	14.40%	12.02%	Italy
18	EG	2.21%	18.88%	16.67%	Egypt
19	UG	2.11%	18.47%	16.36%	Uganda
20	AF	2.10%	50.25%	48.15%	Afghanistan
21	AO	1.93%	27.86%	25.93%	Angola
22	JO	1.92%	5.37%	3.45%	Jordan
23	SI	1.82%	6.25%	4.43%	Slovenia
24	LY	1.65%	10.74%	9.09%	Libya
25	JP	1.56%	3.74%	2.18%	Japan
26	KG	1.33%	8.91%	7.58%	Kyrgyzstan
27	PR	1.25%	11.61%	10.36%	Puerto Rico
28	PA	1.10%	10.81%	9.71%	Panama
29	TW	1.07%	6.35%	5.28%	Taiwan
30	FJ	0.99%	14.29%	13.30%	Fiji

% of users per country who reduced their use of Google’s Public DNS: May to September

Who Turned Google ON?

Rank	CC	Delta ON	MAY%	SEP%	Country
1	KH	21.74%	9.51%	31.25%	Cambodia
2	TN	18.71%	4.32%	23.03%	Tunisia
3	EU	17.03%	8.23%	25.26%	European Union
4	DZ	16.14%	37.18%	53.32%	Algeria
5	NG	15.78%	29.93%	45.71%	Nigeria
6	AM	15.15%	10.08%	25.23%	Armenia
7	MW	14.40%	24.75%	39.15%	Malawi
8	AW	9.13%	2.84%	11.97%	Aruba
9	BD	8.25%	22.19%	30.44%	Bangladesh
10	LK	8.21%	3.75%	11.96%	Sri Lanka
11	ZW	7.63%	22.15%	29.78%	Zimbabwe
12	GH	7.38%	21.38%	28.76%	Ghana
13	IQ	6.96%	22.06%	29.02%	Iraq
14	MV	6.59%	18.92%	25.51%	Maldives
15	BH	5.63%	7.97%	13.60%	Bahrain
16	MM	5.52%	11.44%	16.96%	Myanmar
17	PH	5.25%	7.01%	12.26%	Philippines
18	VN	5.15%	42.03%	47.18%	Vietnam
19	DO	4.35%	5.31%	9.66%	Dominican Republic
20	AR	4.03%	6.95%	10.98%	Argentina
21	SV	4.02%	4.59%	8.61%	El Salvador
22	KZ	3.85%	8.71%	12.56%	Kazakhstan
23	ET	3.11%	7.66%	10.77%	Ethiopia
24	BW	3.09%	1.75%	4.84%	Botswana
25	BR	2.68%	11.86%	14.54%	Brazil
26	HN	2.60%	37.06%	39.66%	Honduras
27	MD	2.59%	3.10%	5.69%	Republic of Moldova
28	TT	2.57%	2.35%	4.92%	Trinidad and Tobago
29	PY	2.48%	5.54%	8.02%	Paraguay
30	TH	2.47%	10.40%	12.87%	Thailand

% of users per country who increased their use of Google's Public DNS: May to September

Who Turned Google ON?

Rank	CC	Delta ON	MAY%	SEP%	Country
1	KH	21.74%	9.51%	31.25%	Cambodia
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5	NG	15.78%	29.93%	45.71%	Nigeria
6	AM	15.15%	10.08%	25.23%	Armenia
7	MW	14.40%	24.75%	39.15%	Malawi
8	AW	9.13%	2.84%	11.97%	Aruba
9	BD	8.25%	22.19%	30.44%	Bangladesh
10	LK	8.21%	[illegible]	11.96%	Sri Lanka
11	ZW	7.63%	[illegible]	[illegible]	Zimbabwe
12	GH	[illegible]	21.38%	28.76%	Ghana
13	IQ	6.96%	22.06%	29.02%	Iraq
14	MV	6.59%	18.92%	25.51%	Maldives
15	BH	5.63%	7.97%	13.60%	Bahrain
16	MM	5.52%	11.44%	16.96%	Myanmar
17	PH	5.25%	7.01%	12.26%	Philippines
18	VN	5.15%	42.03%	47.18%	Vietnam
19	DO	4.35%	5.31%	9.66%	Dominican Republic
20	AR	4.03%	6.95%	10.98%	Argentina
21	SV	4.02%	4.59%	8.61%	El Salvador
22	KZ	3.85%	8.71%	12.56%	Kazakhstan
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30	TH	2.47%	10.40%	12.87%	Thailand

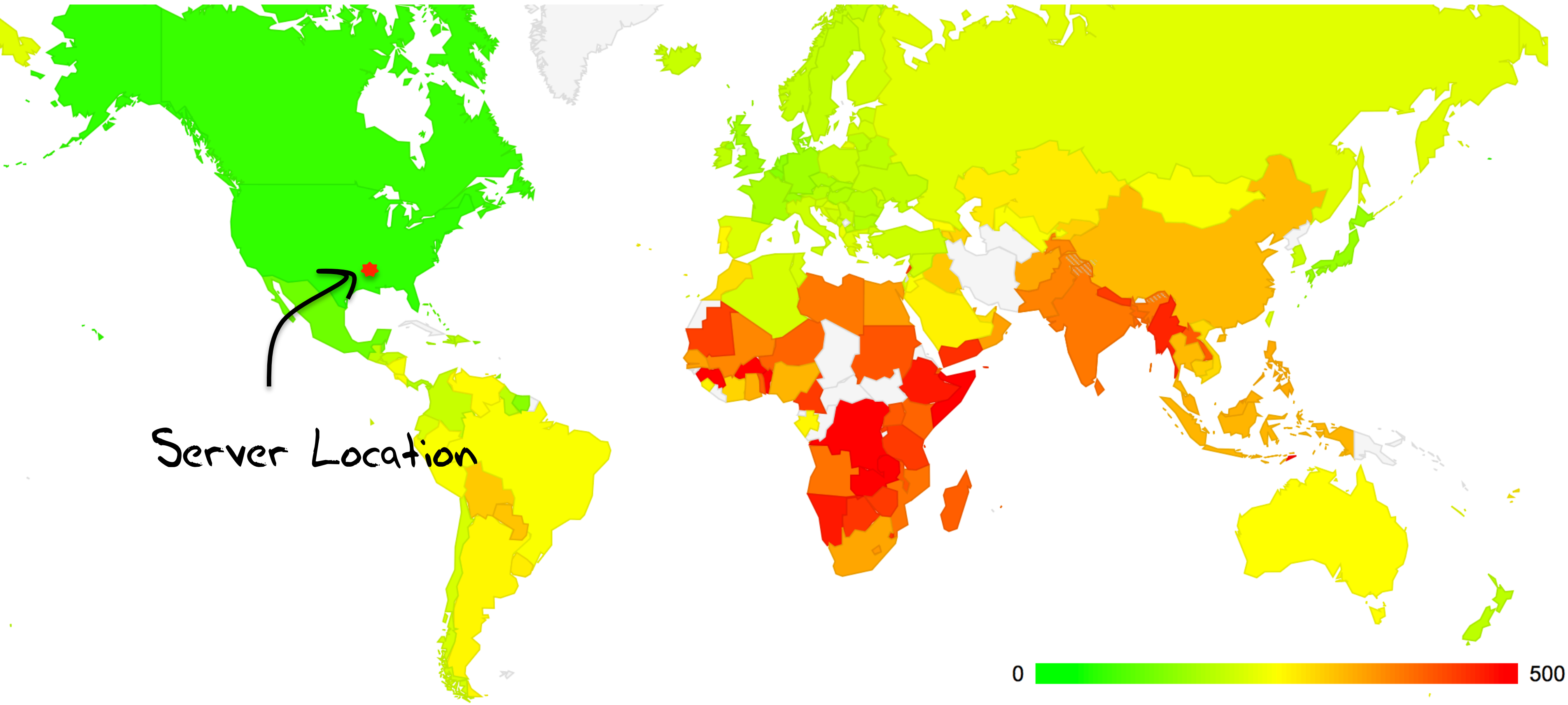
% of users per country who increased their use of Google's Public DNS: May to September

Back to DNSSEC measurement

DNS Performance

How can we measure the time taken to resolve each of the three domain name types (signed, unsigned, badly signed)?

Absolute Measurements don't make much sense…



Average RTT from Client to Server by country of origin (ms)

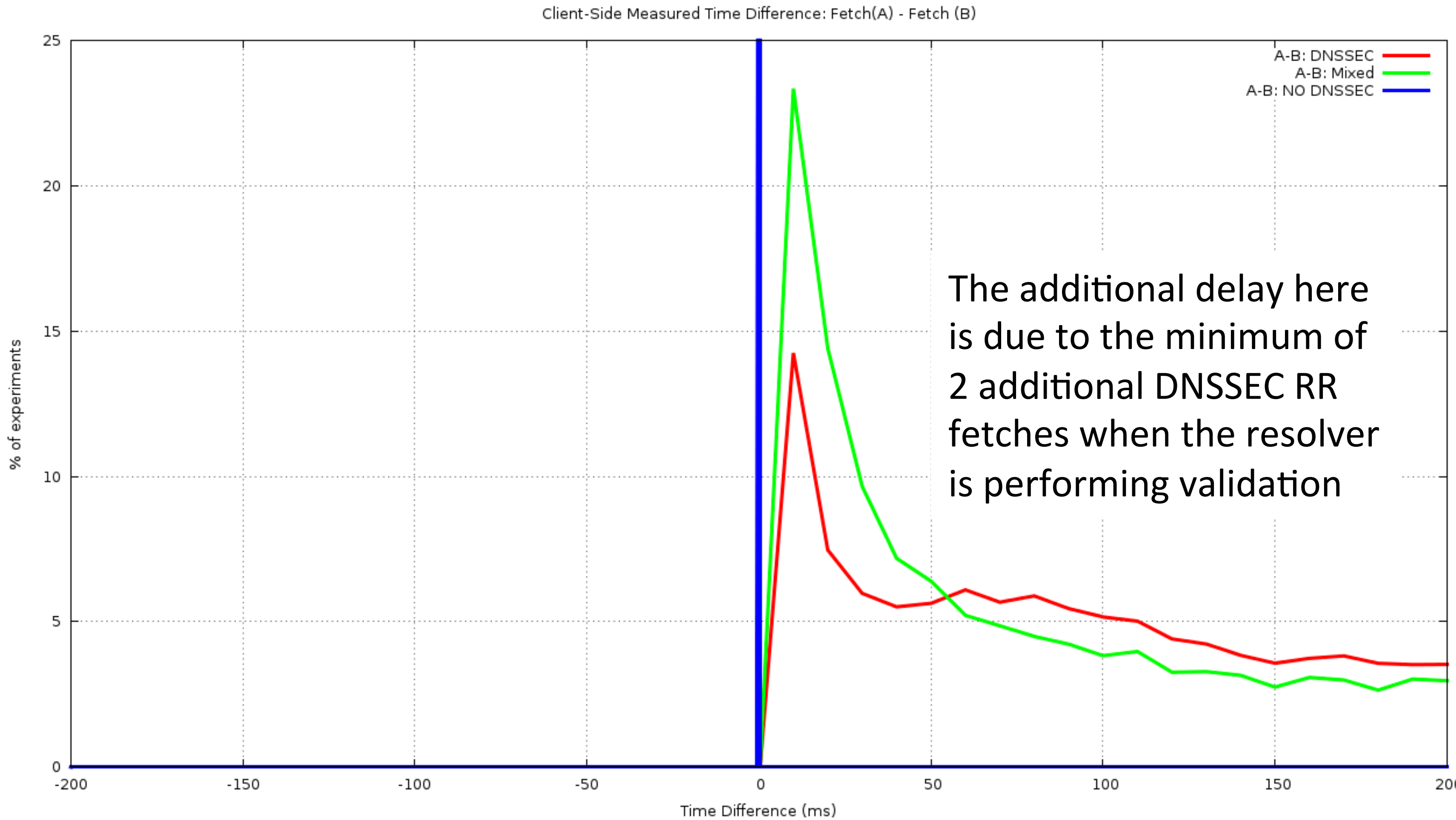
Relative Measurements …

Let’s define the FETCH TIME as the time at the authoritative server from the first DNS query for an object to the HTTP GET command for the same object

- This time should reflect the DNS resolution time and a single RTT interval for the TCP handshake

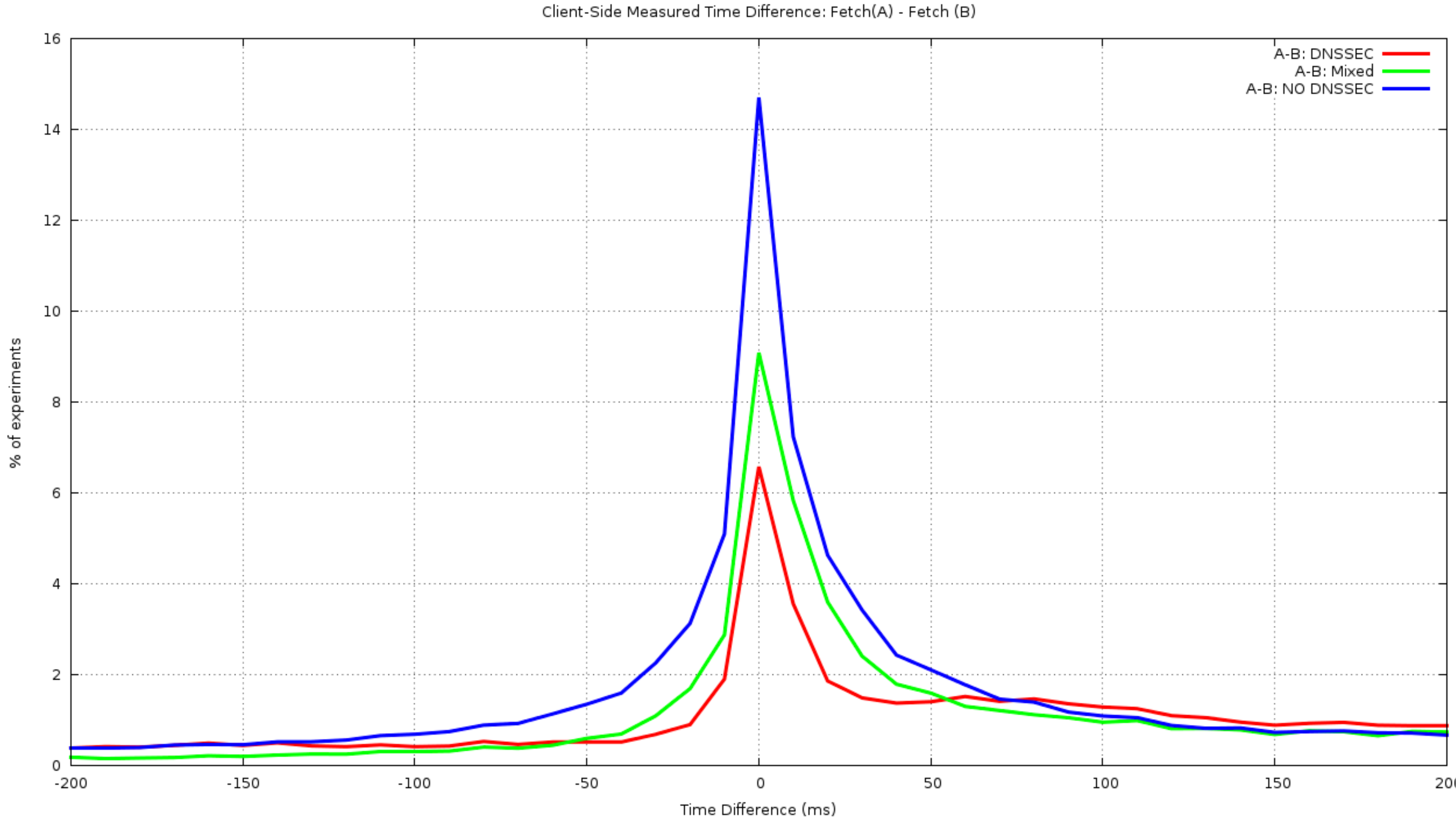
If the “base” fetch time is the time to load an unsigned DNSSEC object, then how much longer does it take to load an object that is DNSSEC-signed?

Theory…



Client-Side Measured Time Difference: Fetch(A) - Fetch (B)
A-B: DNSSEC
A-B: Mixed
A-B: NO DNSSEC
% of experiments
Time Difference (ms)
0
5
10
15
20
25
-200
-150
-100
-50
0
50
100
150
200
The additional delay here is due to the minimum of 2 additional DNSSEC RR fetches when the resolver is performing validation

Result


Client-Side Measured Time Difference: Fetch(A) - Fetch (B)
A-B: DNSSEC
A-B: Mixed
A-B: NO DNSSEC
% of experiments
Time Difference (ms)
0
2
4
6
8
10
12
14
16
-200
-150
-100
-50
0
50
100
150
200

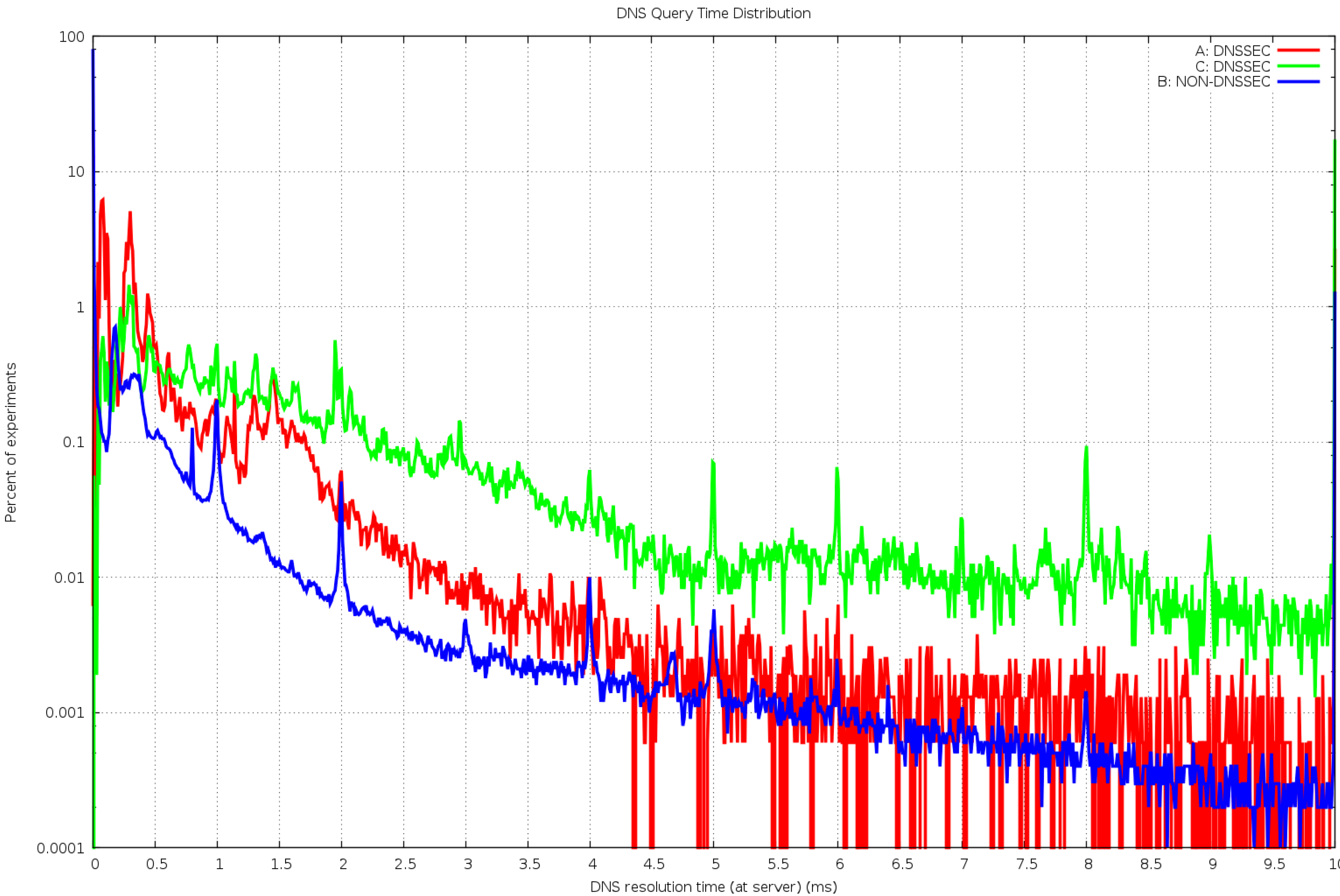
Well…

- That didn't work as intended!
- The client is running a Flash Engine, and it appears when when you use action code to load up additional URLS then:
  - The order that the flash engine performs the load is not the same as the order in the action code!
  - There appears to be an explicit scheduling interval between name resolution phase and the scheduling of the object fetch
  - Flash Engines appear to use a scheduler that is difficult to understand from this data!

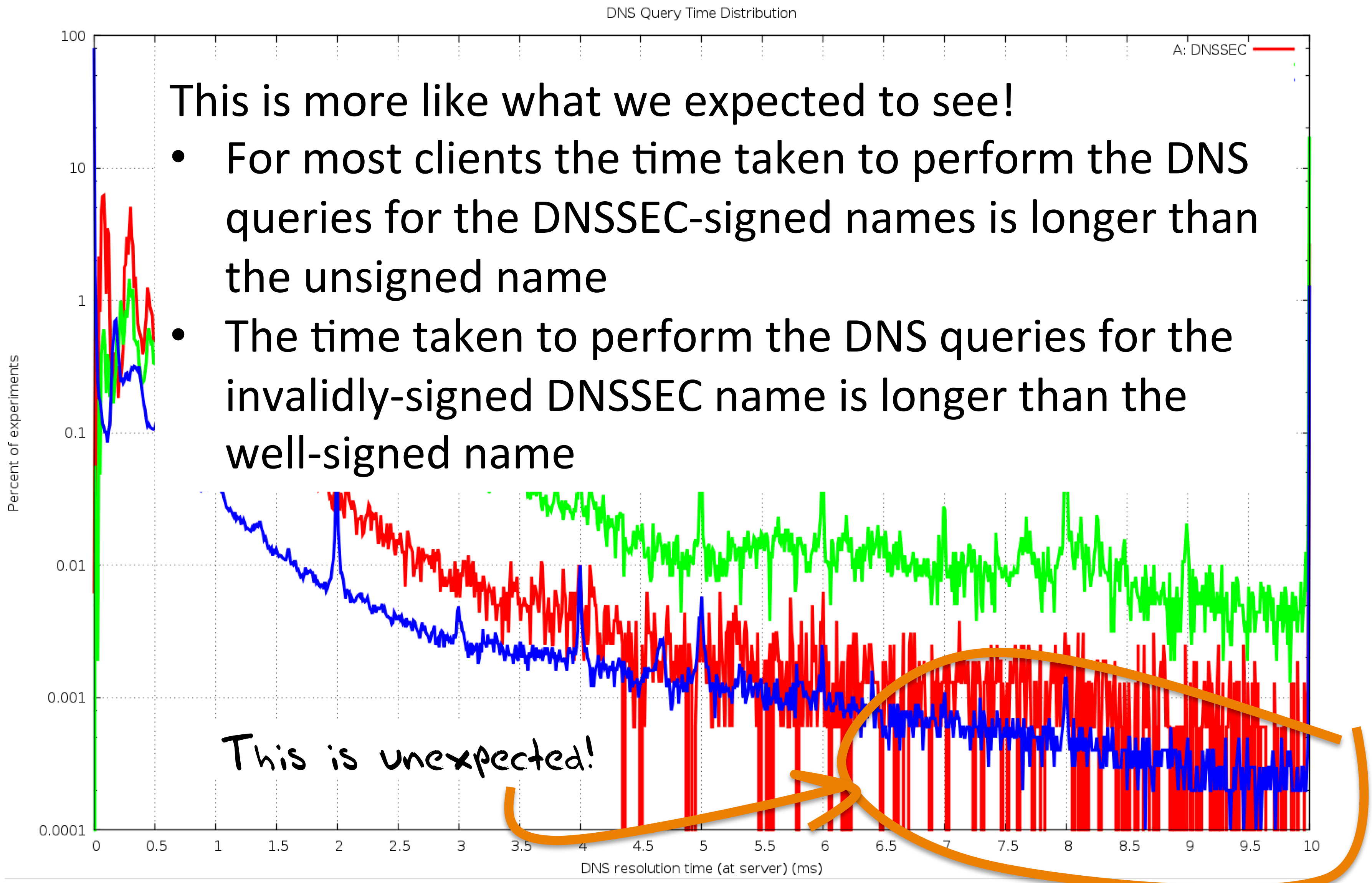
Well…

- There is a slight left/right difference in this data, but its difficult to conclude that fetches of DNSSEC-signed objects is consistently slower for clients using DNSSEC-resolving resolvers
- So lets focus on the DNS queries
  – And measure the elapsed time from the first seen to the last seen DNS query for each instance of the experiment

DNS Query Time



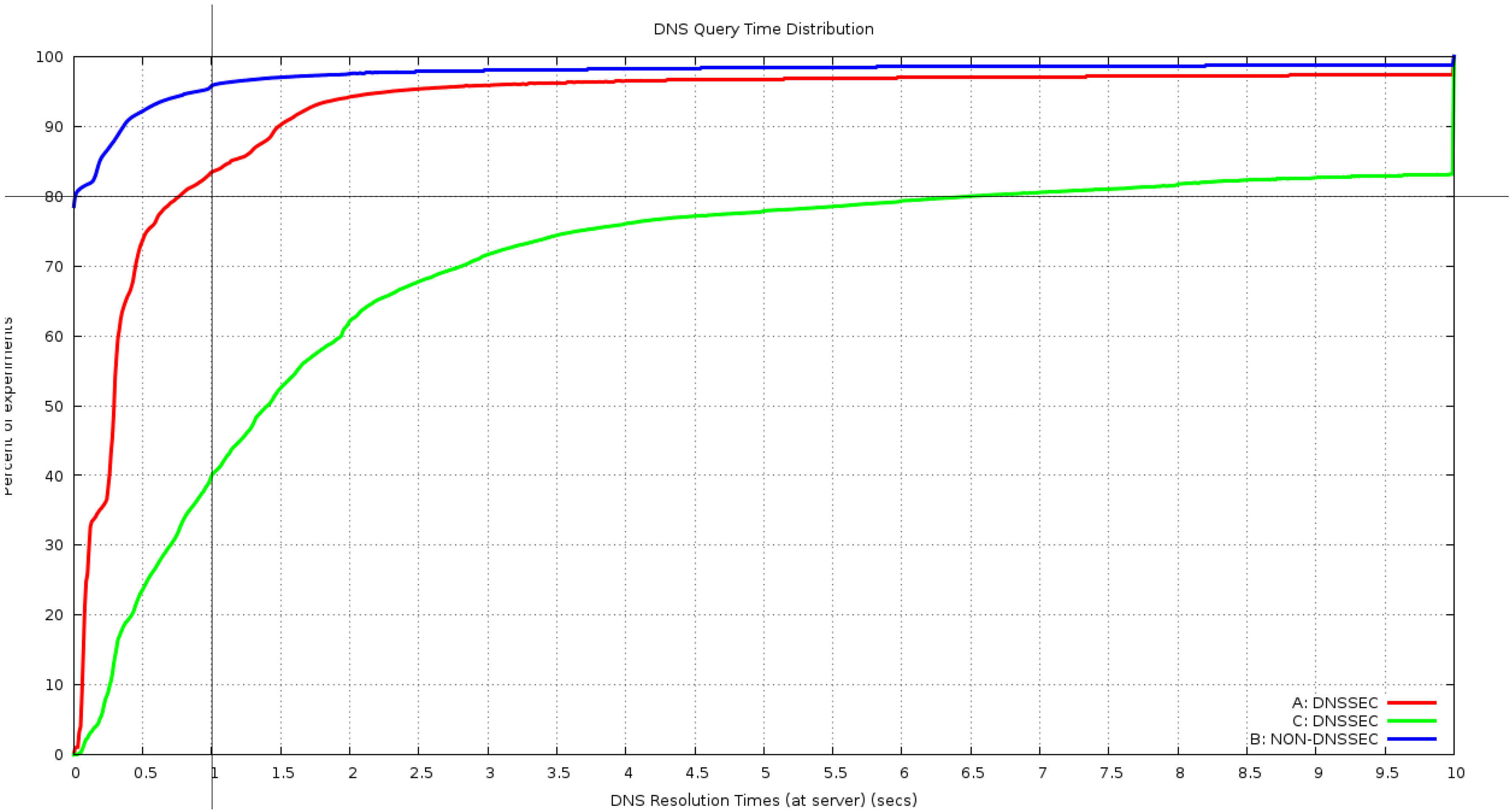
DNS Query Time



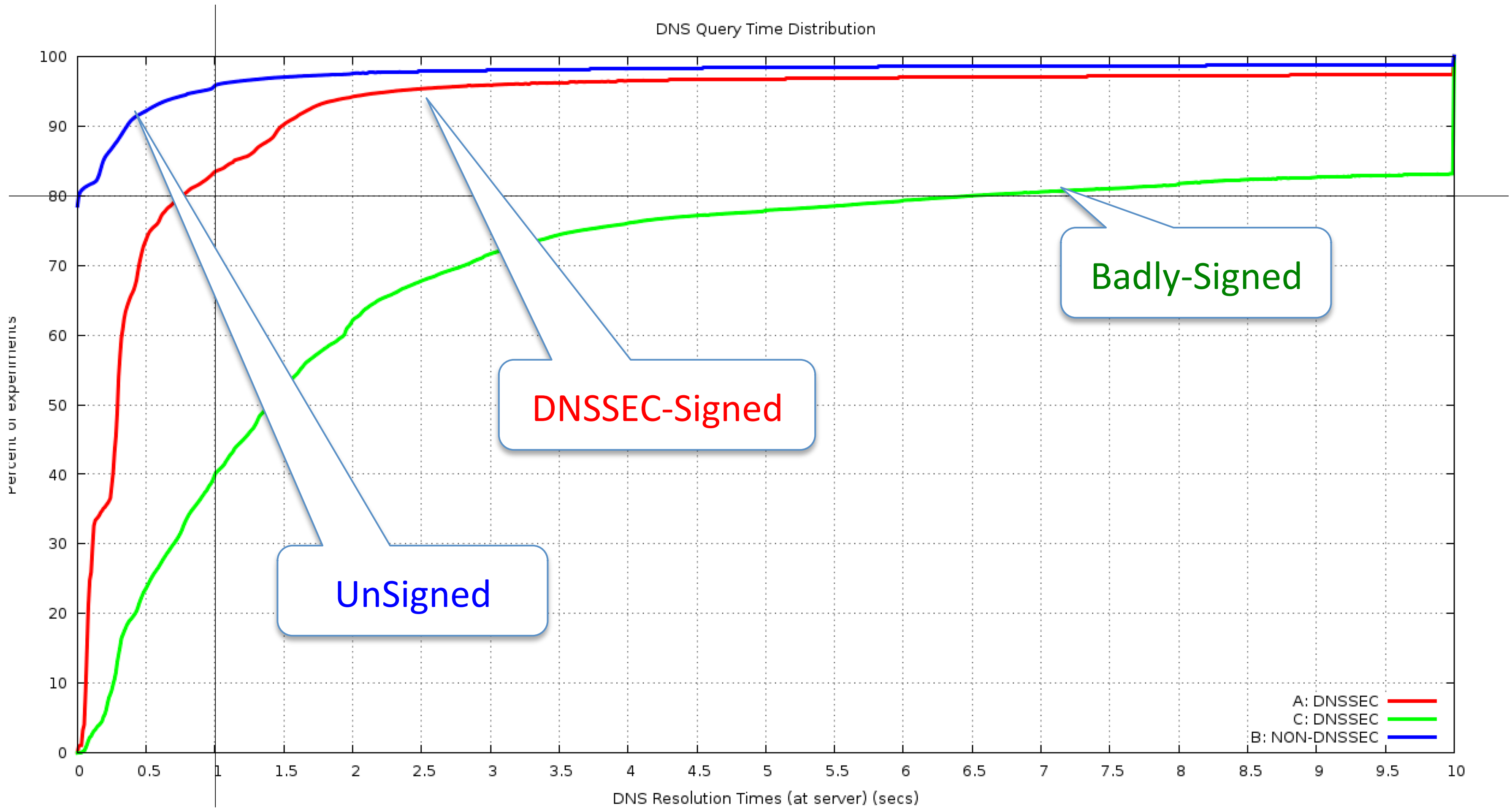
This is more like what we expected to see!

- For most clients the time taken to perform the DNS queries for the DNSSEC-signed names is longer than the unsigned name
- The time taken to perform the DNS queries for the invalidly-signed DNSSEC name is longer than the well-signed name

Cumulative Time Distribution

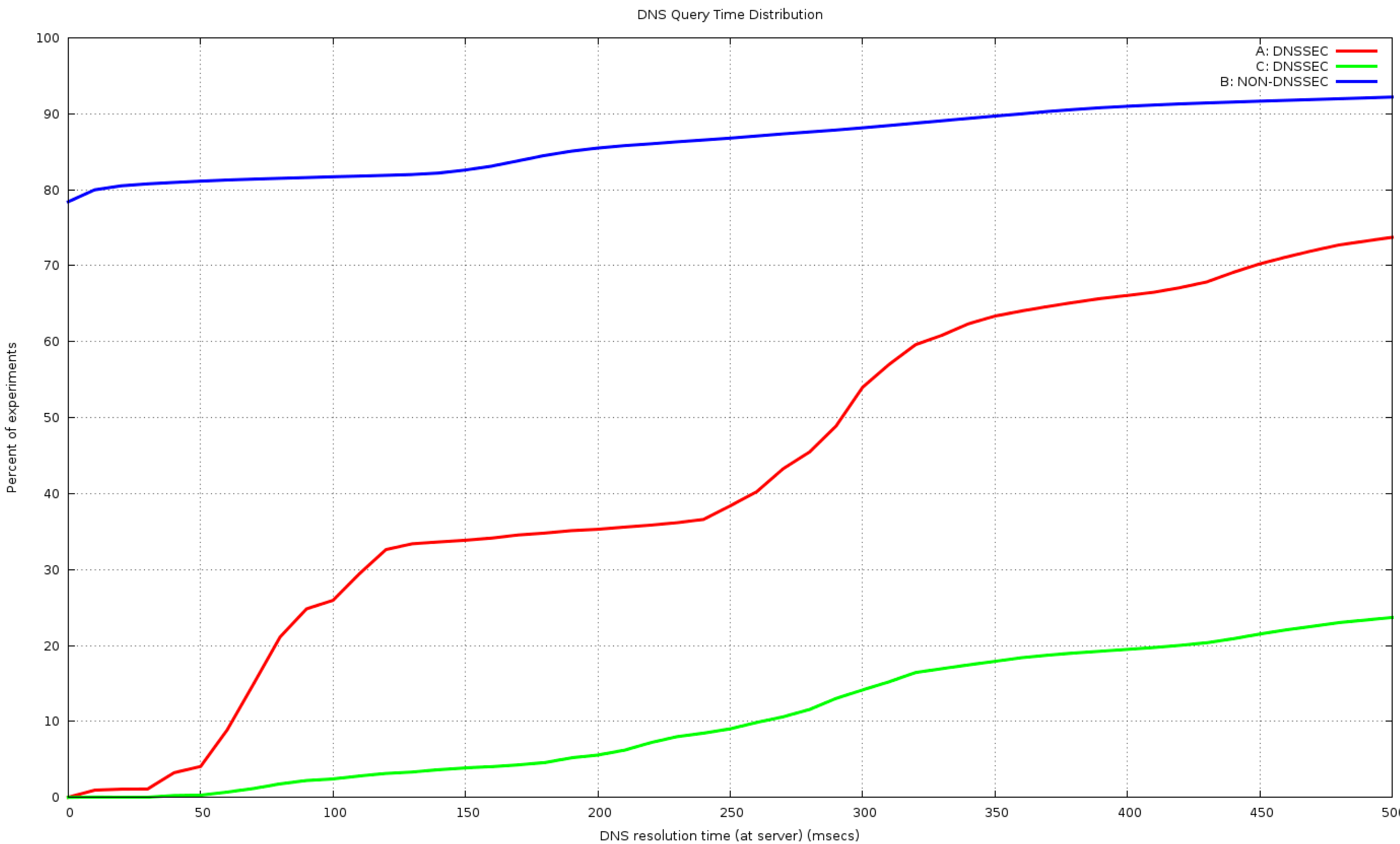


Cumulative Time Distribution



If you perform DNSSEC validation, how long does it take to complete the DNS query process?

The first ½ second



If you perform DNSSEC validation, how long does it take to complete the DNS query process?

What can we say?

- DNSSEC takes longer
  - Additional queries for DS and DNSKEY RRs
  - At a minimum that's 2 DNS query/answer intervals
    - Because it appears that most resolvers serialize and perform resolution then validation
- Badly-Signed DNSSEC takes even longer
  - Resolvers try hard to find a good validation path
  - And the SERVFAIL response causes clients to try subsequent resolvers in their list

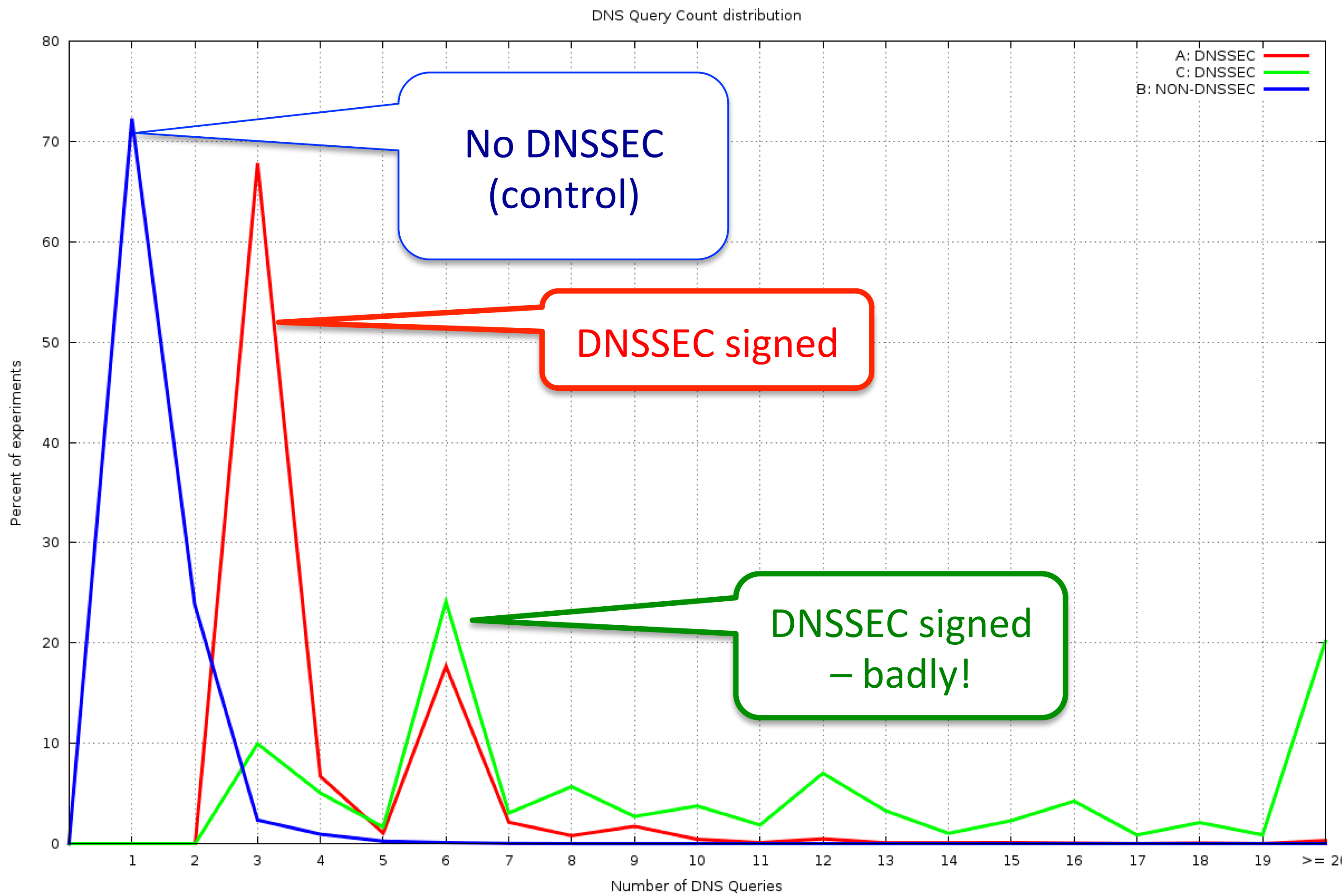
The first ½ second

If you perform DNSSEC validation, how long does it take to complete the DNS query process?

At the other end…

Lets look at performance from the perspective of an Authoritative Name server who serves DNSSEC-signed domain names

DNS Query count per Domain Name



If you perform DNSSEC validation, how many queries are made for you at the Auth. Server?

DNSSEC Performance

At the Authoritative Name Server:

Serving DNSSEC-signed zones = More Queries!

- The Authoritative server will now see additional queries for the DNSKEY and DS RRs for a zone, in addition to the A (and AAAA) queries

2,637,091 launched experiments

4,222,352 unsigned name queries
7,394,794 signed name queries
12,213,677 badly-signed name queries

What if everybody was doing it?

For the control name there are 1.6 queries per experiment

The total profile of queries for the control DNS name was:

3.4M A queries

0.4M AAAA queries

0.4M Other (NS, MX, ANY, SOA, CNAME, TXT, A6) queries

For the signed name, only 12.6% of clients use DNSSEC-aware resolvers, so the theory (2 additional queries per name) says we will see 4.8M queries

But we saw 7.4M queries for the signed DNS Name

- If 12.6% of clients' resolvers using DNSSEC generate an additional 3.1M queries for a signed domain name, what if every DNS resolver was DNSSEC aware?
- That would be 25M queries in the context of our experiment!

A DNSSEC signed zone would see 6 times the query level of an unsigned zone if every resolver performed DNSSEC validation

Good vs Bad for Everyone

If 12.6% of clients performing some form of DNSSEC validation generate 12.2M queries for a badly-signed name, compared to the no-DNSSEC control level of 4.2M queries, what would be the query load if every resolver performed DNSSEC validation for the same badly signed domain?

- In our case that would be 63M queries!

A badly-signed DNSSEC signed zone would seen 15 times the query level of an unsigned zone if every resolver performed DNSSEC validation

Response Sizes

What about the relative traffic loads at the server?

In particular, what are the relative changes in the traffic profile for responses from the Authoritative Server?

DNS Response Sizes

Control (no DNSSEC)
  Query: 124 octets
  Response: 176 octets

DNSSEC-Signed
  Query: (A Record) 124 octets
  Response: 951 Octets

  Query: (DNSKEY Record) 80 octets
  Response: 342 Octets

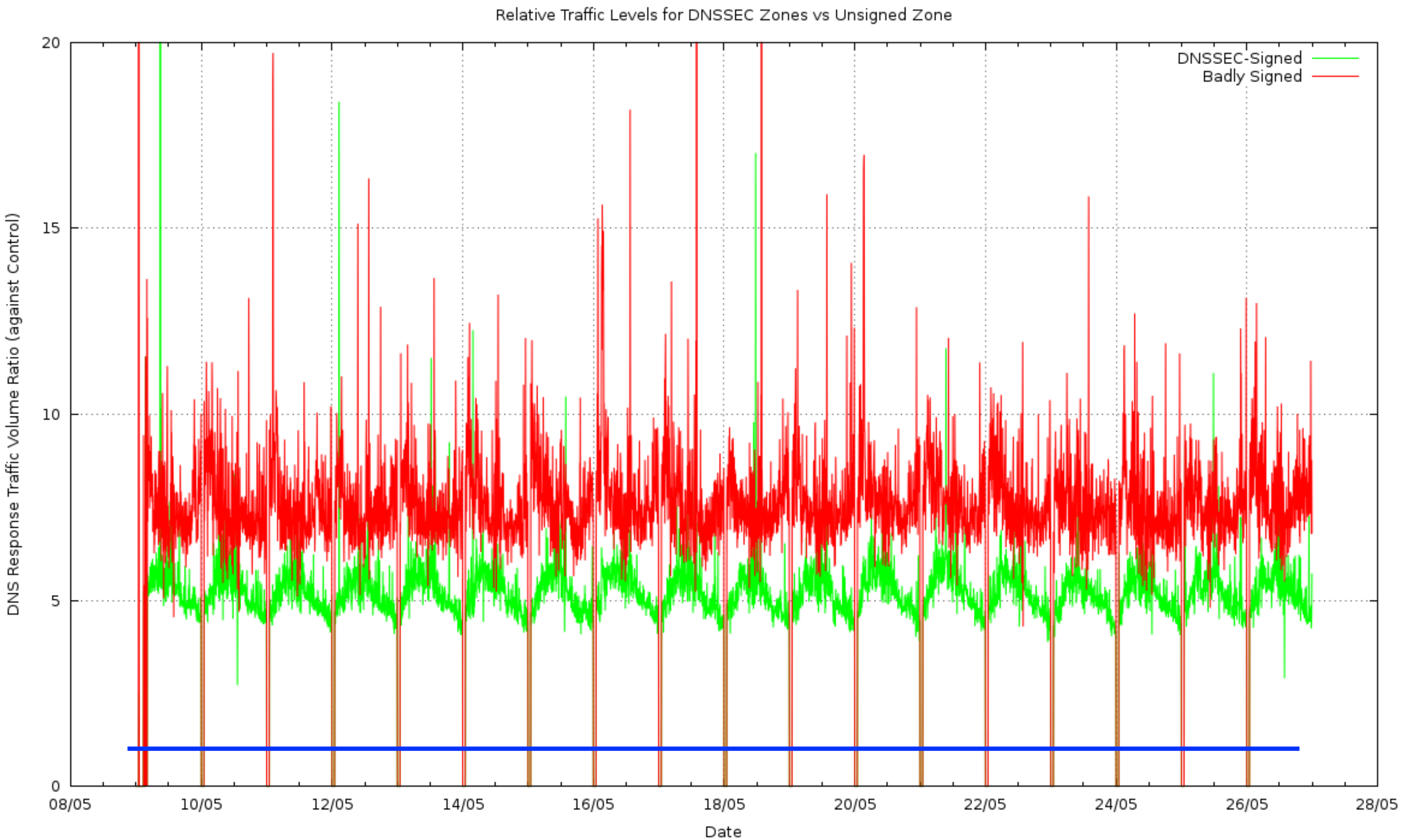
  Query: (DS Record) 80 octets
  Response: 341 Octets

  Total: Query: 284 octets
  Total Response: 1634 octets

These are not constant sizes – the DNS packet sizes of responses relate to the particular name being resolver, the number of keys being used, and the key size

So these numbers are illustrative of what is going on, but particular cases will vary from these numbers

Measurement - Response Traffic Volume



Interpreting Traffic Data

- The validly-signed domain name appears to generate ~5x the traffic volume in responses as compared to the unsigned domain name

- The badly-signed domain name appears to generate ~7.5x the traffic volume in responses

- What's contributing to this?
    1. Setting the DNSSEC OK bit in a query to the signed zone raises the response size from 176 to 951 octets
    2. Performing DNSSEC signature validation adds a minimum of a further 683 octets in the DS and DNSKEY responses

What if you just sign your domain?

Lets start with the hypothetical question: How much more traffic will you be generating at the Authoritative Server if you sign your domain and NO resolvers perform DNSSEC validation?

76% of clients use resolvers who pass our server queries with EDNS0 + DNSSEC OK flag set

- 69% of queries for the unsigned zone
- 75% of queries for the signed zone
- 83% of queries for the badly-signed zone
  - (aside: why are these proportions different for each of these zones?)

If you just sign your zone and <u>no</u> resolvers are performing DNSSEC validation

- Then from the May data, 69% of queries elicit a larger response then the total outbound traffic load is <u>**4x**</u> the traffic load of an unsigned zone

But we saw a rise of <u>**5x**</u> – why?

- That's because 12.6 % of clients are also performing DNSSEC validation

What if everybody was doing it?

If 12.6% of clients performing some form of DNSSEC validation for a signed zone generate around 5 times the traffic as compared to an unsigned zone, then what if every resolver performed DNSSEC validation?

An authoritative server for a DNSSEC signed zone would've seen 13 times the traffic level of an unsigned zone if every resolver performed DNSSEC validation

What if everybody was doing it?

If 12.6% of clients performing some form of DNSSEC validation for a signed zone generate around 5 times the traffic as compared to an unsigned zone, then what if every resolver performed DNSSEC validation?

An authoritative server for a DNSSEC signed zone would've seen 13 times the traffic level of an unsigned zone if every resolver performed DNSSEC validation

A badly-signed DNSSEC zone would seen 31 times the traffic level of an unsigned zone

DNSSEC means you probably need more Server Foo

- Its probably a good idea to plan the serve the worst case: a badly signed zone

- In which case you may want to consider provisioning the authoritative name servers with processing capacity to handle **15x the query load,** and **30x the generated traffic load** that you would need to serve an unsigned zone

It could be (a lot) better

"Real" performance of DNSSEC could be a lot better than what we have observed here

We have deliberately negated any form of resolver caching

- Every client receives a "unique" signed URL, and therefore every DNS resolver has to to perform A, DS and DNSKEY fetches for the unique label
- The Ad placement technique constantly searches for "fresh eyeballs", so caching is not as efficient as it could be
- Conventional DNS caching would dramatically change this picture
  - Our 16 day experiment generated 12,748,834 queries
  - A 7 day TTL would cut this to a roughly estimated 2M queries

And it could be (a lot) worse

For the invalid DNSSEC case we deliberately limited the impact of invalidity on the server by using a single NS

- DNSSEC invalidity is not handled consistently by resolvers
- Some resolvers will perform an exhaustive check of all possible NS validation paths in the event of DNSSEC validation failure

  See "Roll Over and Die" (http://www.potaroo.net/ispcol/2010-02/rollover.html)

- In this experiment we used a single NS record for the domains
- If we had chosen to use multiple nameservers, or used a deeper-signed label path, or both, on the invalid label, then the query load would've been (a lot) higher

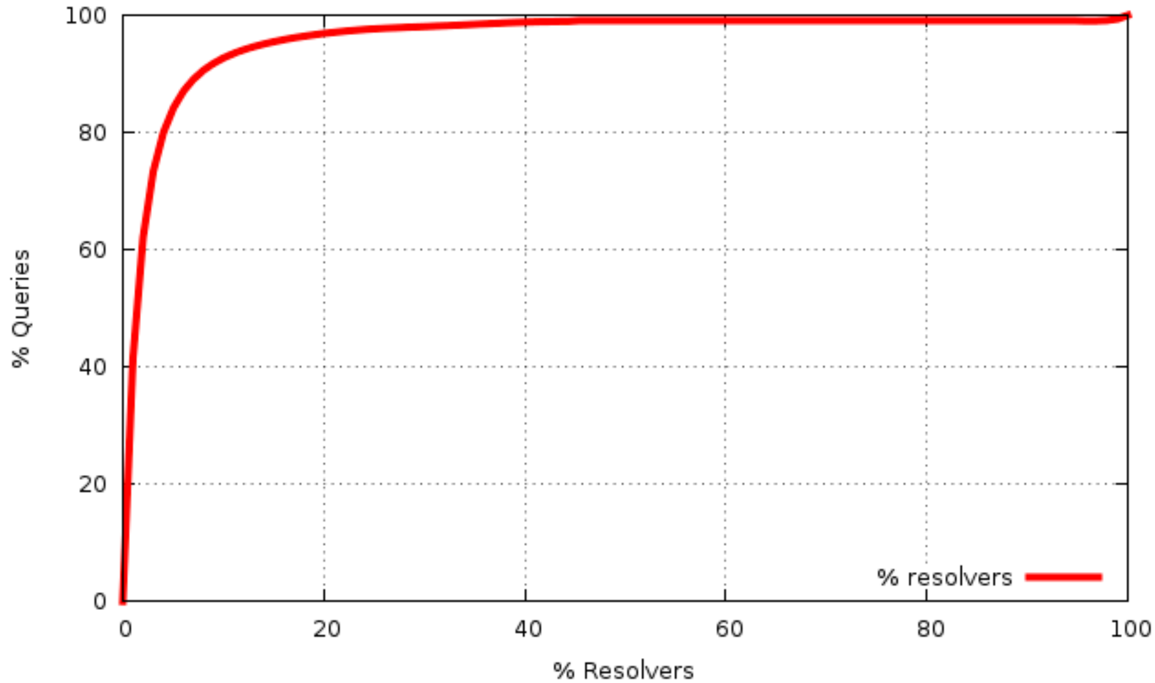
• Resolver caching of invalidly signed data is also unclear – so a break in the DNSSEC validation material may also change the caching behaviour of resolvers, and increase load at the server

Some things to think about

- DNSSEC generates very large responses from very small queries
  - Which makes it a highly effective DDOS amplifier
  - Is relying on BCP38 going to work?
  - Do we need to think about DNS over TCP again?
  - But how many resolvers/firewalls/other middleware stuff support using TCP for DNS?
  - What's the impact on the authoritative server load and caching recursive resolver load when moving from UDP to TCP?

Some things to think about

- 1% of visible resolvers provide the server with 58% of the seen queries
- A few resolvers handle a very significant proportion of the total query volume
- But there are an awful lot of small, old, and poorly maintained resolvers running old code out there too!



Some things to think about

SERVFAIL is not just a "DNSSEC validation is busted" signal

- clients start walking through their resolver set asking the same query
- Which delays the client and loads the server
  - The moral argument: Failure should include a visible cost!
  - The expedient argument: nothing to see here, move along!

Maybe we need some richer signaling in the DNS for DNSSEC validation failure

Some things to think about

Olde Code never seems to die out

- We still see A6 queries!

So what about Key rollover and RFC5011 support?

- How many resolvers don't support RFC5011 in their key management?
- We don't know because we can't get resolvers to signal their capability
- If we roll the TA, and if resolvers have hand-installed trust, and don't implement RFC5011 signalling
  - How many will say "broken DNSSEC" when the old sigs expire?
  - How many will re-query per NS high in the tree to the authoritative servers?
  - What percentage of of worldwide DNSSEC will do this?

Some things to think about

Why do up to 80% of queries have EDNS0 and the DNSSEC OK flag set, yet only 1/10 of that (8.3% of clients) perform DNSSEC validation?

How come we see relatively more queries with the DNSSEC OK flag set for queries to domains in signed zones?

And relatively more when the zone is invalidly signed?

Some things to think about

- Google’s Public DNS is currently handling queries from 7.5% of the Internet’s end client population
  - That’s around 1 in 13 users
  - In this time of heightened awareness about corporate and state surveillance, and issues around online anonymity and privacy, how do we feel about this level of use of Google’s Public DNS Service?

Thanks!

Questions?