

Measuring DNSSEC

Geoff Huston & George Michaelson
APNIC Labs
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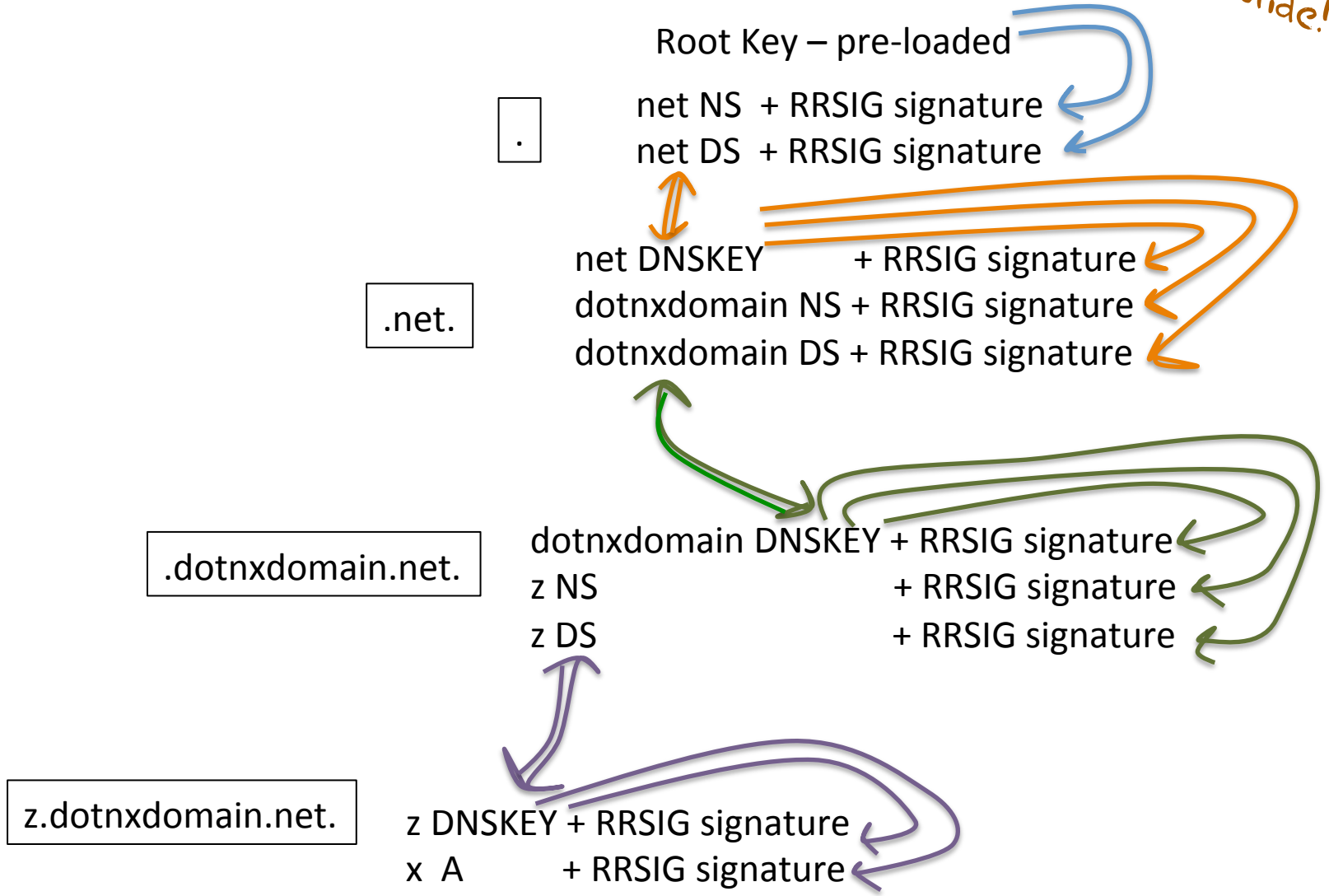
What is DNSSEC?

(the one slide version)

- DNSSEC adds **digital signatures** to the responses generated by authoritative servers for a zone
- A **validating DNS resolver** can use this signature to verify that the response has not been altered or tampered with in any way
- DNSSEC uses the key used to sign the root of the DNS as its **Trust Anchor**
- **Signature Validation** in DNSSEC establishes a sequence of overlapping digital signatures from the Trust Anchor to the signature being verified
- DNSSEC uses some new RRs to contain **digital signatures**, **public keys** and **key hashes**

Signing "x.z.dotnxdomain.net"

(the other slide!)



Validating "x.z.dotnxdomain.net"

(i lied - it took THREE slides!)

1. Fetch **A** record for x.z.dotnxdomain.net. from z.dotnxdomain.net. (+ signature)
2. Fetch **DNSKEY** record z.dotnxdomain.net. from z.dotnxdomain.net. (+ signature)
3. Fetch **DS** record z.dotnxdomain.net. from dotnxdomain.net. (+ signature)
4. Fetch **DNSKEY** record dotnxdomain.net. from dotnxdomain.net. (+ signature)
5. Fetch **DS** record dotnxdomain.net. from .net. (+ signature)
6. Fetch **DNSKEY** record .net. from .net. (+ signature)
7. Fetch **DS** record .net. from . (+ signature)
8. Use **local root key value** to validate signature

DNSSEC Validation queries

What are the questions?

1. What proportion of DNS resolvers are DNSSEC-capable?
2. What proportion of users are using DNSSEC-validating DNS resolvers?
3. Where are these users?
4. How long does DNSSEC validation take for a client?

The Experiment

- Use code embedded in an online ad to retrieve a set of URLs
- Embed the unique id generation and the ad control in flash code:
 - Retrieve three URLs, all with a unique domain name:
 - one from a DNSSEC-signed domain, validly signed,
 - one from a DNSSEC-signed domain with an invalid DS record, and
 - one from a non-DNSSEC domain)
 - Use a 10 second timer to POST results to the server (to distinguish between incomplete and completed test runs)
- Enrol 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!)

Experimental Technique

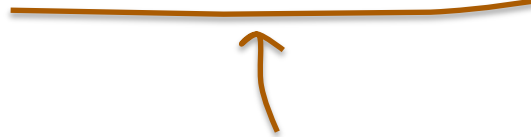
The experimental URLs:

- 1 <http://z1.2d609.z.dotnxdomain.net/1x1.png?d.t10000.u2d609.s1360816588.i868.v6022.2d609.z.dotnxdomain.net>
- 2 <http://z1.2d609.z.dashnxdomain.net/1x1.png?e.t10000.u2d609.s1360816588.i868.v6022.2d609.z.dashnxdomain.net>
- 3 <http://z1.2d60a.z.dotnxdomain.net/1x1.png?f.t10000.u2d60a.s1360816588.i868.v6022.2d609.z.dotnxdomain.net>

Experimental Technique

The experimental URLs:

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Experiment identifier

Quasi-unique subdomain identifier
(The experiment cycles through
250,000 unique subdomain values)

Experimental Technique

The experimental URLs:

DNSSEC Signed - Valid DNSSEC records

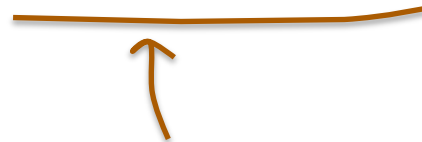
1 <http://z1.2d609.z.dotnxdomain.net/1x1.png?d.t10000.u2d609.s1360816588.i868.v6022.2d609.z.dotnxdomain.net>

NOT DNSSEC Signed

2 <http://z1.2d609.z.dashnxdomain.net/1x1.png?e.t10000.u2d609.s1360816588.i868.v6022.2d609.z.dashnxdomain.net>

DNSSEC Signed - iNValid DNSSEC records

3 <http://z1.2d60a.z.dotnxdomain.net/1x1.png?f.t10000.u2d60a.s1360816588.i868.v6022.2d609.z.dotnxdomain.net>



Common Experiment identifier

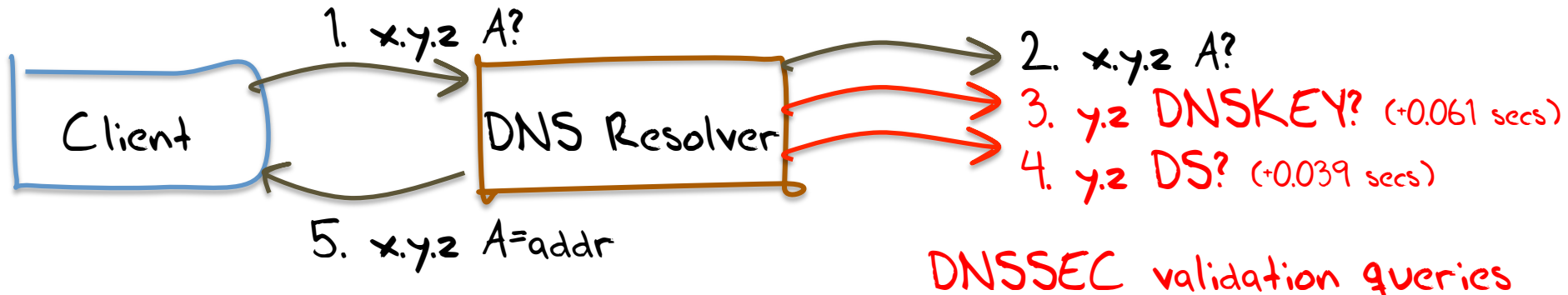
Quasi-unique subdomain identifiers

Example: A DNSSEC-Validating Resolver

09-Feb-2013 20:10:53.828 queries: client 98.16.104.6#8904 query: z1.155c3.z.dotnxdomain.net IN A -EDC

09-Feb-2013 20:10:53.889 queries: client 98.16.104.6#24902 query: 155c3.z.dotnxdomain.net IN DNSKEY -EDC

09-Feb-2013 20:10:53.928 queries: client 98.16.104.6#25718 query: 155c3.z.dotnxdomain.net IN DS -EDC



Experiment Run

8 – 17 February 2013

2,549,816 experiments were executed

Each experiment queried for a name contained in a DNSSEC-signed unique subdomain of a common zone and then fetched a web blot

The DNS name server and Web server were colocated on the same measurement server

DNS Resolvers

- How many unique IP addresses queried for experiment domains in dotnxdomain.net?
- How many of these DNS resolvers also queried for the DNSKEY RR of dotnxdomain.net?

DNS Resolvers

- How many unique IP addresses queried for experiment domains in dotnxdomain.net?

75,123

- How many of these DNS resolvers also queried for DNSKEY RRs in dotnxdomain.net?

3,940

Q1: What proportion of DNS
resolvers are DNSSEC-
capable?

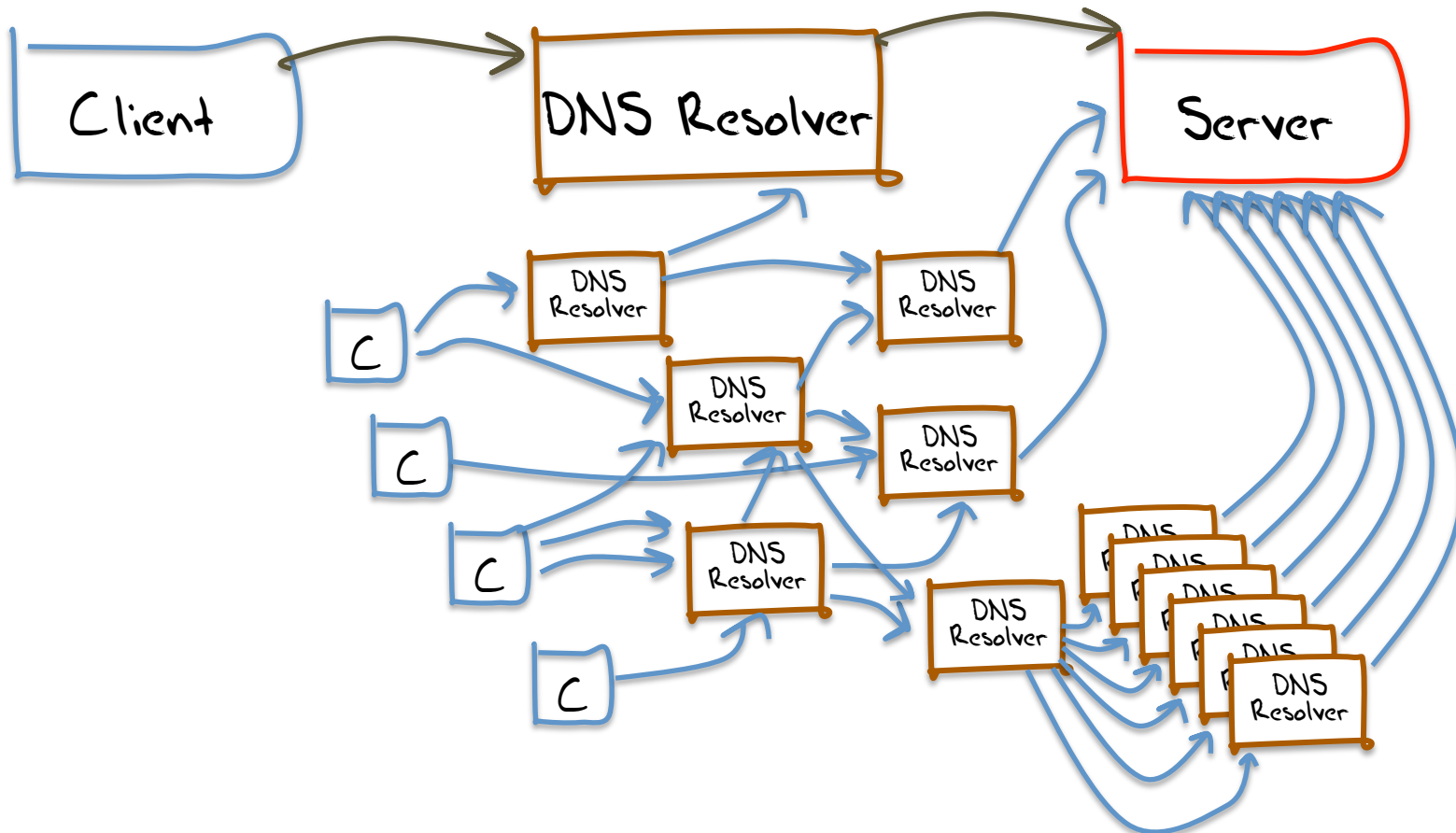
5.2% of visible DNS resolvers appear to be performing
DNSSEC validation*

* Assuming that querying for a DNSKEY or DS record
indicates that some form of DNSSEC validation is going on.

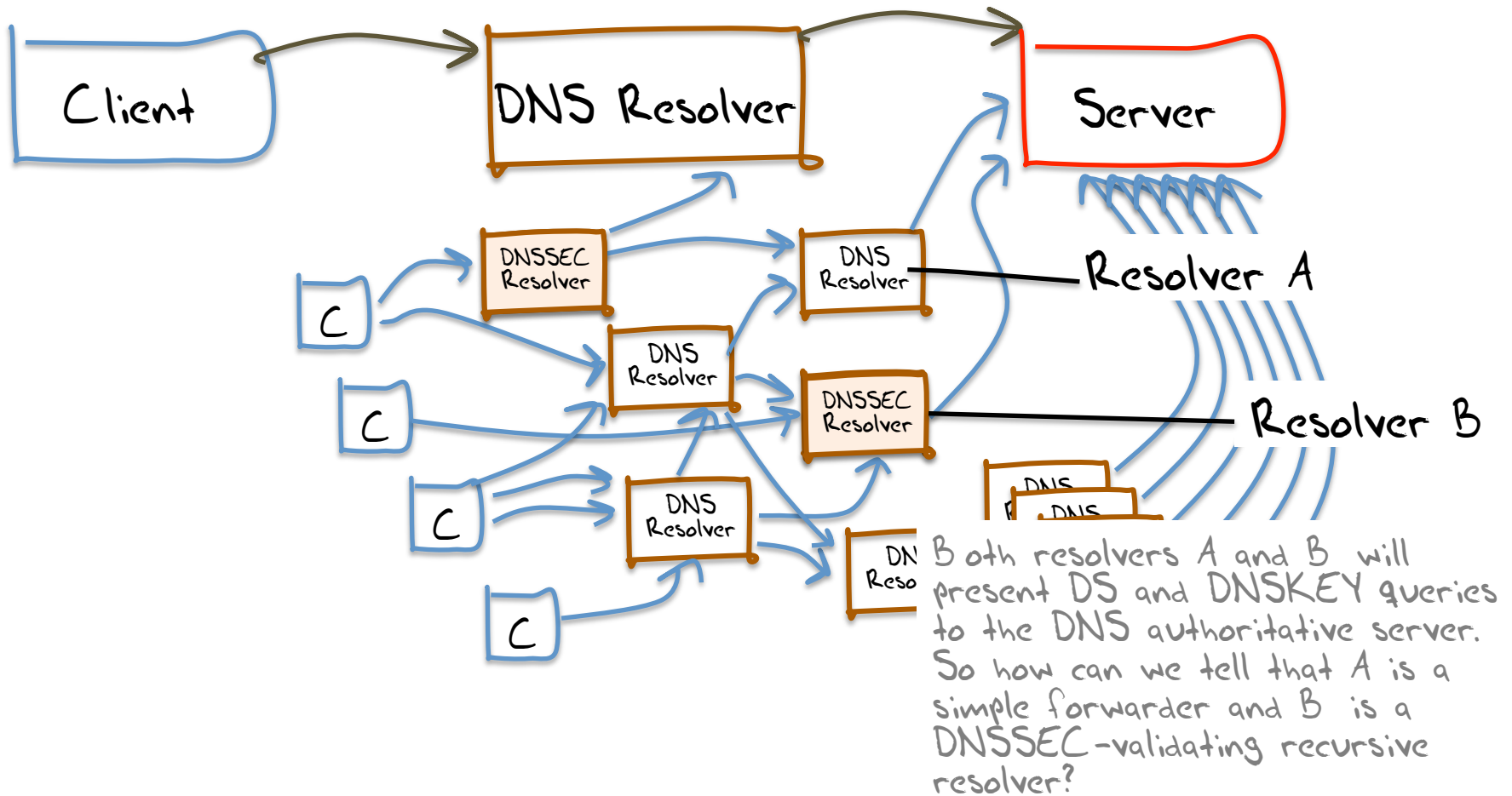
A simple view of the DNS



But the real world of DNS is a bit more complicated



How can we interpret what we are seeing?



A DNSSEC-validating resolver will perform DNSSEC validation as part of the query resolution process. This implies that the resolver will submit a DNSKEY query “very soon” after the first A query for **every** domain it queries:

```
$ dig e1.x1.x.dotnxdomain.net @validating.dns.resolver
```

Time (ms)	Query Type	Name
0	A?	e1.x1.x.dotnxdomain.net
389	DNSKEY?	x1.x.dotnxdomain.net
586	DS?	x1.x.dotnxdomain.net
778	DNSKEY?	x.dotnxdomain.net
977	DS?	x.dotnxdomain.net



DNSSEC validation queries

Subsequent queries for domains in the same parent zone will not repeat the DNSSEC validation queries, as this information is already cached by the resolver

```
$ dig e2.x1.x.dotnxdomain.net @validating.dns.resolver
```

Time (ms)	Query Type	Name
2000	A?	e2.x1.x.dotnxdomain.net

In this experiment every domain name is unique, so we can expect that every DNSSEC-validating resolver will make a DNSKEY and a DS query for every domain name where it has queried an A record:

Resolvers that made a DNSKEY query: 3,940

a) Resolvers that made DNSKEY queries for ALL A queries: 1,697

These 1,697 resolvers look to be DNSSEC validating resolvers, or they are a DNS Forwarder used exclusively by clients who use validating resolvers.

In this experiment every domain name is unique, so we can expect that every DNSSEC-validating resolver will make a DNSKEY and a DS query for every domain name where it has queried an A record:

Resolvers that made a DNSKEY query: 3,940

a) Resolvers that made DNSKEY queries for ALL A queries: 1,697

b) Resolvers that made DNSKEY queries for SOME A queries: 2,041

These 2,041 resolvers look to be DNSSEC Forwarders. Behind these Forwarders are a number of client resolvers, only SOME of which are performing DNSSEC validation

In this experiment every domain name is unique, so we can expect that every DNSSEC-validating resolver will make a DNSKEY and a DS query for every domain name where it has queried an A record:

Resolvers that made a DNSKEY query: 3,940

- a) Resolvers that made DNSKEY queries for ALL A queries: 1,697
- b) Resolvers that made DNSKEY queries for SOME A queries: 2,041
- b) Resolvers that ONLY made DNSKEY and/or DS query (no A): 202

These 202 resolvers look to be part of some DNS Forwarder server farm, where queries are spread across multiple visible resolver instances. There may be DNSSEC validation functions going on either in the server farm or by resolver clients of the farm, but it's not possible to clearly determine where and how DNSSEC validation is happening

Spot the Difference...

How can we tell the difference between a DNSSEC-capable DNS Recursive Resolver and a DNS Forwarder?

Count only those resolvers who issue DS and DNSKEY queries following a query for the A record of the DNS name all of the time.

Resolvers:

- How many unique IP addresses queried for experiment domains in dotnxdomain.net?

75,123

- How many of these DNS resolvers also (immediately) queried for the DNSKEY RR of dotnxdomain.net?

1,697*

That's **2.3%** of the seen resolver set

* This is an upper bound value – a lower bound is those 1,241 visible DNS resolvers that performed all their DNSSEC validation queries in strict order with no additional queries (1.7%)

Who does DNSSEC Validation?

We see both large-scale resolvers used by many clients (such as Google's Open DNS resolvers) and small-scale resolvers used by a single client

Is DNSSEC validation more prevalent in large or small resolvers?

"Small-scale" Resolvers

Look at those resolvers that are associated with 10 or fewer clients

How many "small" resolvers were seen: **54,014**

How many perform DNSSEC validation: **1,226**

What's the DNSSEC-active proportion of these resolvers: **2.3%**

"Larger" Resolvers:

Look at those resolvers that are associated with more than 10 clients

How many "big" resolvers were seen: **19,935**

How many perform DNSSEC validation: **399**

What's the DNSSEC-validating proportion of these resolvers: **2.0%**

"Infrastructure" Resolvers:

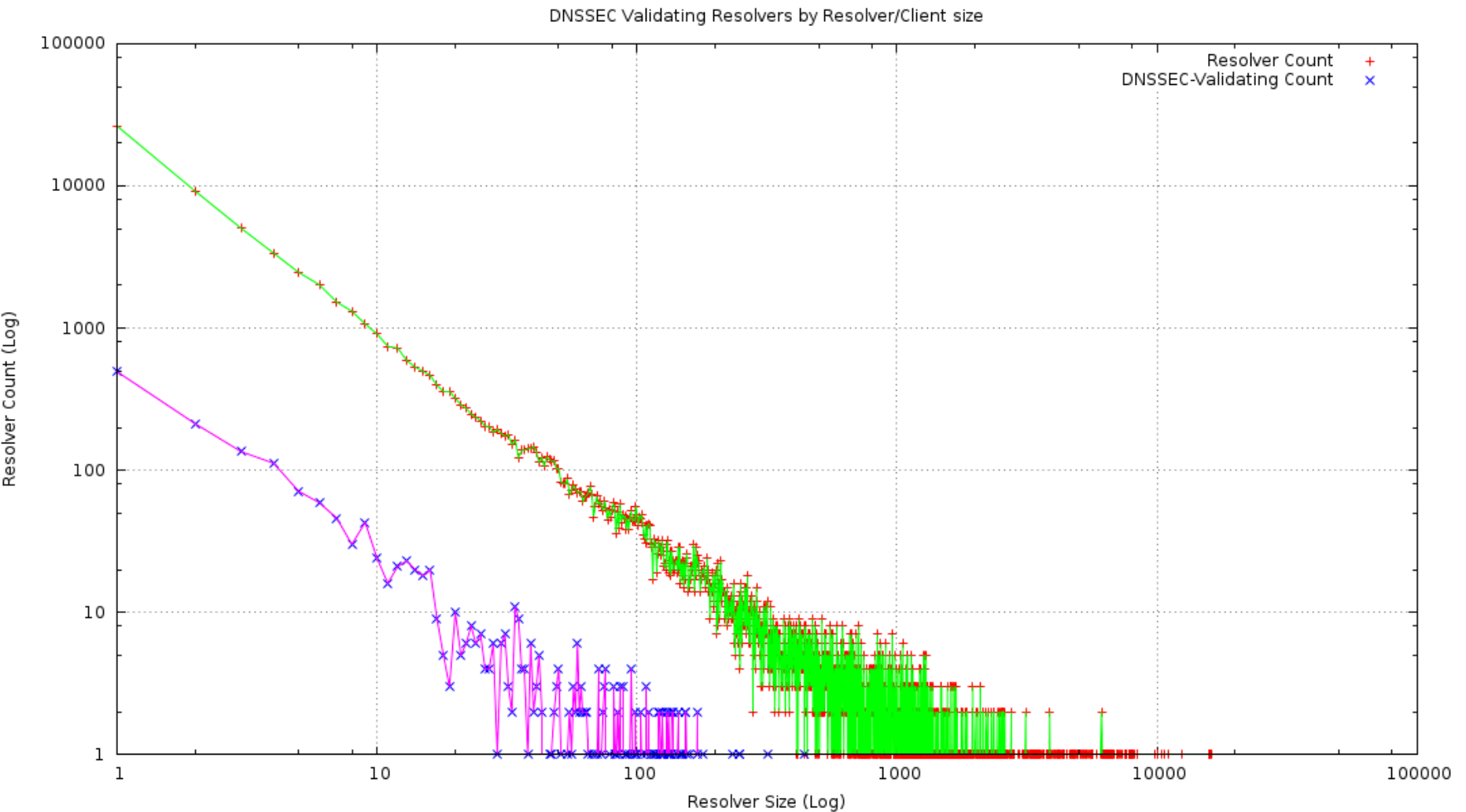
Look at those resolvers that are associated with more than 1,000 clients

How many "very big" resolvers were seen: **1,241**

How many perform DNSSEC validation: **0**

What's the DNSSEC-validating proportion of these resolvers: **0.0%**

DNSSEC validation by resolver size



The Biggest Resolvers (by Origin AS)

DNSSEC?	Clients	Resolvers	Origin AS	Origin AS Name	Country
FORWARDER	494,219	328	AS15169	GOOGLE - Google Inc.	USA
NON-DNSSEC	259,394	592	AS4766	KIXS-AS-KR Korea Telecom	Korea
NON-DNSSEC	227,484	478	AS4134	CHINANET-BACKBONE No.31,Jin-rong Street	China
NON-DNSSEC	206,982	39	AS16880	TRENDMICRO Global IDC and Backbone of Trend Micro Inc.	USA
FORWARDER	167,599	148	AS7922	COMCAST-7922 - Comcast Cable Communications, Inc.	USA
NON-DNSSEC	138,160	163	AS9318	HANARO-AS Hanaro Telecom Inc.	Korea
NON-DNSSEC	133,266	274	AS3786	LGDACOM LG DACOM Corporation	Korea
NON-DNSSEC	103,592	790	AS4837	CHINA169-BACKBONE CNCGROUP China169 Backbone	China
NON-DNSSEC	74,304	1,120	AS3462	HINET Data Communication Business Group	Taiwan
NON-DNSSEC	65,954	8,737	AS3356	LEVEL3 Level 3 Communications	USA
NON-DNSSEC	54,222	212	AS5384	EMIRATES-INTERNET Emirates Telecommunications Corporation	UAE
NON-DNSSEC	51,709	135	AS5483	HTC-AS Magyar Telekom plc.	Hungary
NON-DNSSEC	50,552	72	AS3329	Hellas OnLine Electronic Communications S.A.	Greece
NON-DNSSEC	50,511	244	AS8151	Uninet S.A. de C.V.	Mexico
NON-DNSSEC	50,016	228	AS6799	OTENET-GR Ote SA (Hellenic Telecommunications Organisation)	Greece
NON-DNSSEC	47,363	101	AS9737	TOTNET-TH-AS-AP TOT Public Company Limited	Thailand
NON-DNSSEC	45,911	88	AS27699	TELECOMUNICACOES DE SAO PAULO S/A - TELESP	Brazil
NON-DNSSEC	39,970	40	AS12322	PROXAD Free SAS	France
NON-DNSSEC	39,913	358	AS7132	SBIS-AS AS for SBIS-AS	USA
NON-DNSSEC	39,591	158	AS4788	TMNET-AS-AP TM Net, Internet Service Provider	Malaysia
NON-DNSSEC	39,365	117	AS45758	TRIPLETNET-AS-AP Triplet Internet Internet service provider	Thailand
NON-DNSSEC	39,278	63	AS7470	TRUEINTERNET-AS-AP TRUE INTERNET Co.,Ltd.	Thailand
NON-DNSSEC	38,921	61	AS1267	ASN-INFOSTRADA WIND Telecomunicazioni S.p.A.	Italy
NON-DNSSEC	37,146	151	AS24560	AIRTELBROADBAND-AS-AP Bharti Airtel Ltd., Telemedia Services	India
NON-DNSSEC	36,525	72	AS15557	LDCOMNET Societe Francaise du Radiotelephone S.A	France
NON-DNSSEC	33,596	169	AS18101	RELIANCE-COMMUNICATIONS-IN Reliance Communications Ltd. MUMBAI	India
NON-DNSSEC	33,447	48	AS4771	NZTELECOM Telecom New Zealand Ltd.	New Zealand
NON-DNSSEC	31,076	290	AS4713	OCN NTT Communications Corporation	Japan
NON-DNSSEC	30,899	115	AS25019	SAUDINETSTC-AS Autonomus System Number for SaudiNet	Saudi Arabia
FORWARDER	26,771	7	AS8400	TELEKOM-AS TELEKOM SRBIJA a.d.	Serbia

The Biggest DNSSEC-Validating Resolvers (by Origin AS)

DNSSEC?	Clients	Resolvers	Origin AS	Origin AS Name	Country
DNSSEC	7,219	89	AS28573	NET servicos de Comunicacao S.A.	Brazil
DNSSEC	681	6	AS39651	COMHEM-SWEDEN Com Hem Sweden	Sweden
DNSSEC	596	4	AS3737	PTD-AS - PenTeleData Inc.	USA
DNSSEC	547	15	AS23944	SKYBB-AS-AP AS-SKYBroadband SKYCable Corporation	Philippines
DNSSEC	517	11	AS2119	TELENOR-NEXTEL Telenor Norge AS	Norway
DNSSEC	465	1	AS5645	TEKSAVVY-TOR TekSavvy Solutions Inc. Toronto	Canada
DNSSEC	326	2	AS17705	INSPIRENET-AS-AP InSPire Net Ltd	New Zealand
DNSSEC	308	2	AS12735	ASTURKNET TurkNet Iletisim Hizmetleri A.S	Turkey
DNSSEC	299	8	AS8767	MNET-AS M-net Telekommunikations GmbH, Germany	Germany
DNSSEC	253	2	AS29854	WESTHOST - WestHost, Inc.	USA
DNSSEC	196	3	AS36907	TVCaboAngola	Angola
DNSSEC	174	4	AS16960	Cablevision Red, S.A de C.V.	Mexico
DNSSEC	168	2	AS13156	AS13156 Cabovisao,SA	Portugal
DNSSEC	157	3	AS53128	NET_BZ Divinetworks for NET	Brazil
DNSSEC	154	1	AS3352	TELEFONICA-DATA-ESPANA TELEFONICA DE ESPANA	Spain
DNSSEC	152	3	AS28926	DONTELE-AS Telenet LLC	Ukraine
DNSSEC	152	3	AS42109	ADC-AS ADC - Armenian Datacom Company	Armenia
DNSSEC	151	2	AS9044	SOLNET BSE Software GmbH	Switzerland
DNSSEC	148	3	AS35753	ITC ITC AS number	Saudi Arabia
DNSSEC	145	5	AS1239	AS1239 SprintLink Global Network	USA
DNSSEC	136	1	AS25388	ASK-NET Stream Group Autonomous System	Poland
DNSSEC	132	6	AS9050	RTD ROMTELECOM S.A	Romania
DNSSEC	126	1	AS15600	FINECOM Finecom Telecommunications AG	Switzerland
DNSSEC	124	3	AS42652	DELUNET inexio Informationstechnologie und Telekommunikation KGaA	Germany
DNSSEC	121	2	AS6772	IMPNET-AS Improware AG	Switzerland
DNSSEC	118	1	AS21412	CGATES-AS UAB "Cgates"	Lithuania
DNSSEC	118	2	AS27831	Colombia M?vil	Colombia
DNSSEC	116	5	AS11139	CWRIN CW BARBADOS	Dominica
DNSSEC	111	4	AS8473	BAHNHOF Bahnhof Internet AB	Sweden
DNSSEC	111	1	AS3225	GULFNET-KUWAIT Gulfnet Kuwait	Kuwait

Now lets look at Clients:

- How many unique experiment identifiers completed DNS queries for objects named in the experiment?
- How many clients exclusively used DNSSEC-validating resolvers?

Clients:

- How many unique experiment identifiers completed DNS queries for objects named in the experiment?

2,549,816

- How many clients **exclusively** used DNSSEC-validating resolvers when resolving the domain name with invalid DNSSEC credentials?

77,021 (3.0%)

Clients:

- How many unique experiment identifiers completed WEB fetches for objects named in the experiment?

2,323,888

- How many clients **exclusively** used DNSSEC-validating resolvers (i.e. used DNSSEC validating resolvers and DID NOT fetch the badly-signed object)

52,177 (2.2%)

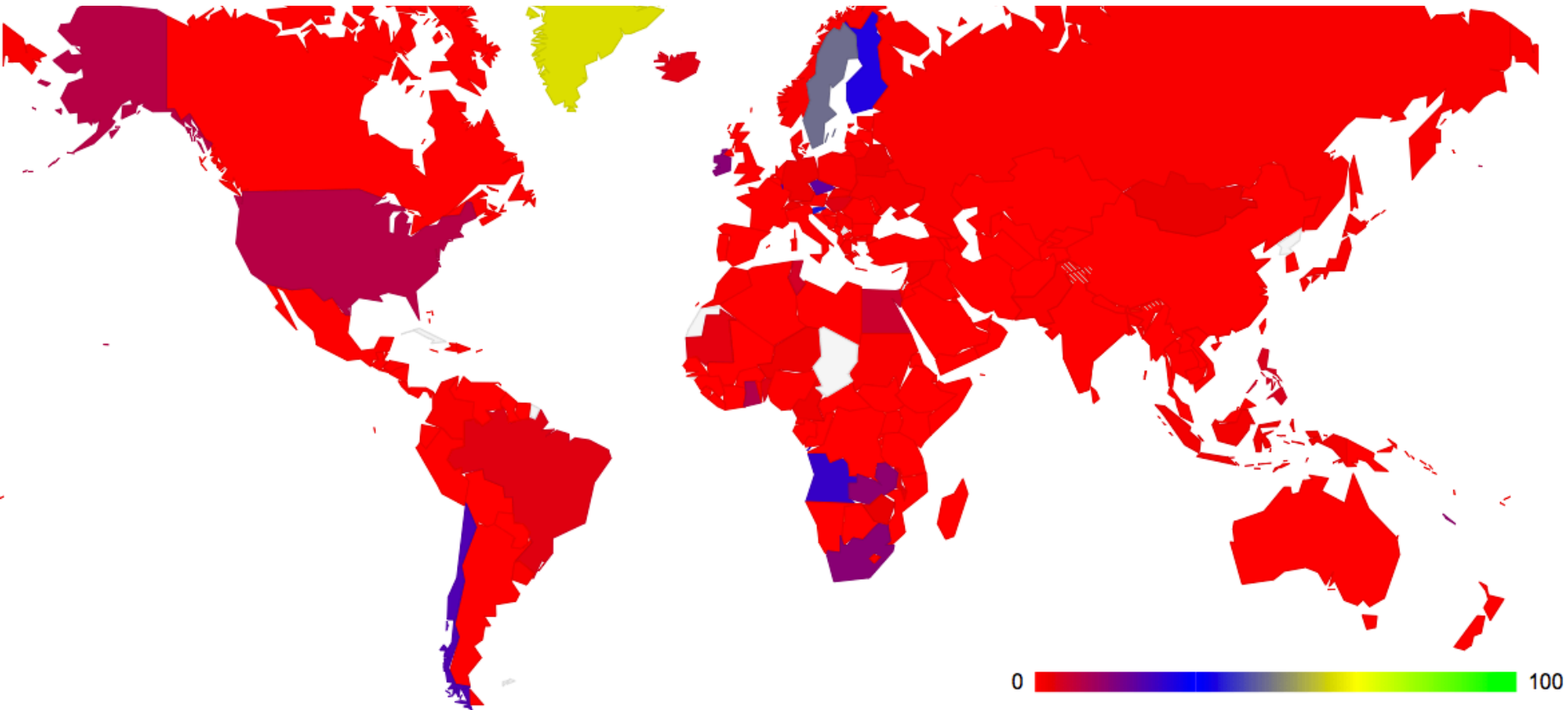
Q2: What proportion of users are DNSSEC-validating resolvers?

2.2% of end client systems are using **only** DNS resolvers that appear to be performing DNSSEC validation*

- Actually a further 3% of clients perform DNSSEC queries, but appear to use a combination of DNSSEC validating resolvers and non-validating resolvers. Obviously this negates any benefit from using DNSSEC validation.

Q3: Where can we find
DNSSEC-validating clients?

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Client use of DNSSEC by country (%)
January 2012

The top of the country list

% who validate DNSSEC	Total	Validate DNSSEC	
62.50%	8	5	GL Greenland
47.99%	2,865	1,375	SE Sweden
39.20%	250	98	AG Antigua and Barbuda
38.43%	5,961	2,291	SI Slovenia
28.81%	3,568	1,028	FI Finland
25.70%	249	64	AO Angola
24.94%	826	206	LU Luxembourg
22.91%	10,587	2,426	CL Chile
20.83%	14,055	2,928	CZ Czech Republic
20.00%	10	2	AI Anguilla
15.53%	5,427	843	IE Ireland
15.33%	4,422	678	ZA South Africa
14.66%	341	50	ZM Zambia
14.21%	190	27	NC New Caledonia
11.54%	1,326	153	BB Barbados
10.11%	722	73	GH Ghana
9.25%	197,284	18,242	US United States of America
6.67%	25,538	1,703	EG Egypt
5.93%	4,268	253	TN Tunisia
5.01%	19,262	965	PH Philippines
4.37%	75,221	3,290	HU Hungary
4.35%	69	3	BJ Benin
4.27%	122,402	5,221	BR Brazil
4.17%	480	20	IS Iceland
3.90%	77	3	MR Mauritania
3.80%	158	6	MW Malawi
3.70%	27	1	LI Liechtenstein
3.06%	1,371	42	ZW Zimbabwe
2.97%	1,412	42	MN Mongolia

The top of the country list

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3.06%	1,371	42	ZW Zimbabwe
2.97%	1,412	42	MN Mongolia
2.81%	9,514	267	BY Belarus
2.63%	41,199	1,082	DE Germany
2.03%	10,186	207	CH Switzerland
1.91%	38,764	741	ID Indonesia
1.56%	9,982	156	SK Slovakia
1.52%	52,794	802	UA Ukraine
1.37%	124,134	1,702	JP Japan
1.36%	53,387	725	PL Poland
1.30%	100,399	1,306	GR Greece
1.17%	15,326	179	CO Colombia
1.04%	3,255	34	DK Denmark
0.86%	3,735	32	NO Norway
0.82%	2,426	20	EE Estonia
0.82%	1,827	15	UY Uruguay

Ranking only those CCs with more than 1000 sample points in this experiment run (100 CC's)

The bottom of the list

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% who validate DNSSEC	Total	Validate DNSSEC	
0.08%	10,949	9	PE Peru
0.07%	1,510	1	UG Uganda
0.05%	23,915	13	ES Spain
0.05%	4,149	2	KE Kenya
0.05%	4,330	2	LV Latvia
0.04%	11,451	5	HK Hong Kong
0.04%	29,740	11	TW Taiwan
0.03%	11,823	4	IL Israel
0.03%	22,185	7	SG Singapore
0.03%	3,253	1	PR Puerto Rico
0.02%	6,299	1	MD Republic of Moldova
0.01%	8,350	1	GE Georgia
0.01%	11,233	1	HR Croatia
0.01%	28,048	2	SA Saudi Arabia
0.00%	261,419	6	KR Republic of Korea
0.00%	1,239	0	JM Jamaica
0.00%	19,022	0	AE United Arab Emirates
0.00%	2,308	0	ME Montenegro
0.00%	2,291	0	OM Oman
0.00%	1,423	0	YE Yemen
0.00%	4,674	0	VE Venezuela
0.00%	1,725	0	BH Bahrain
0.00%	1,250	0	SN Senegal
0.00%	2,459	0	DO Dominican Republic
0.00%	12,280	0	QA Qatar
0.00%	2,999	0	AL Albania
0.00%	3,708	0	MK Macedonia
0.00%	2,636	0	JO Jordan
0.00%	1,389	0	PY Paraguay
0.00%	1,230	0	TT Trinidad and Tobago

Ranking only those CCs with more than 1000 sample points in this experiment run (100 CC's)

DNSSEC-Validating Clients by AS - the top AS's

% who validate DNSSEC		Total	Validate DNSSEC	
↓		↓	↓	
0.85%	AS4134	143,050	1,210	CN CHINANET-BACKBONE No.31,Jin-rong Street China
0.00%	AS4766	117,955	5	KR KIXS-AS-KR Korea Telecom Republic of Korea
0.02%	AS4837	74,866	12	CN CHINA169-BACKBONE CNCGROUP China169 Backbone China
1.32%	AS16880	74,807	989	US TRENDMICRO Global IDC and Backbone of Trend Micro Inc. United States of America
0.00%	AS9318	53,138	0	KR HANARO-AS Hanaro Telecom Inc. Republic of Korea
0.02%	AS6799	43,952	8	GR OTENET-GR Ote SA (Hellenic Telecommunications Organisation) Greece
0.03%	AS6830	34,823	11	AT LGI-UPC Liberty Global Operations B.V. Austria
52.02%	AS7922	32,477	16,893	US COMCAST-7922 - Comcast Cable Communications, Inc. United States of America
0.01%	AS3269	32,334	4	IT ASN-IBSNAZ Telecom Italia S.p.a. Italy
0.10%	AS4788	31,097	31	MY TMNET-AS-AP TM Net, Internet Service Provider Malaysia
0.00%	AS4771	30,960	1	NZ NZTELECOM Telecom New Zealand Ltd. New Zealand
0.00%	AS17858	30,313	0	KR KRNIC-ASBLOCK-AP KRNIC Republic of Korea
0.01%	AS8151	28,188	2	MX Uninet S.A. de C.V. Mexico
0.06%	AS9829	25,241	15	IN BSNL-NIB National Internet Backbone India
0.83%	AS45595	24,486	204	PK PKTELECOM-AS-PK Pakistan Telecom Company Limited Pakistan
19.80%	AS28573	24,188	4,789	BR NET Servicos de Comunicacao S.A. Brazil
0.00%	AS5483	24,081	1	HU HTC-AS Magyar Telekom plc. Hungary
0.44%	AS36947	22,105	97	DZ ALGTEL-AS Algeria
0.00%	AS3462	20,988	0	TW HINET Data Communication Business Group Taiwan
0.13%	AS18881	20,672	26	BR Global Village Telecom Brazil
0.08%	AS7738	20,131	16	BR Telecomunicacoes da Bahia S.A. Brazil
4.03%	AS1241	20,009	806	EU FORTHNET-GR Forthnet European Union
0.57%	AS17974	19,406	110	ID TELKOMNET-AS2-AP PT Telekomunikasi Indonesia Indonesia
0.00%	AS3786	18,878	0	KR LGDACOM LG DACOM Corporation Republic of Korea
0.00%	AS25019	18,759	0	SA SAUDINETSTC-AS Autonomus System Number for SaudiNet Saudi Arabia

Ranking only those ASs with more than 30 sample points in this experiment run (3,370 AS's)

DNSSEC-Validating Clients by AS - the top Validating

AS's

% who
validate
DNSSEC



Total



Validate
DNSSEC



% who validate DNSSEC	AS	Total	Validate DNSSEC	AS Name
93.00%	AS29854	671	624	US WESTHOST - WestHost, Inc. United States of America
89.34%	AS53340	122	109	US VEGASNAP - VegasNAP, LLC United States of America
82.93%	AS56194	41	34	MN TELEMEX_COMMUNICATION-MN 3rd Floor Azmon Building Mongolia
76.79%	AS8307	56	43	SI Telekom Slovenije d.d. Slovenia
76.79%	AS55862	56	43	IN WNET-IN Wan & Lan Internet Pvt Ltd India
76.47%	AS197643	34	26	UA DKT-AS DKT LLC Ukraine
75.00%	AS38484	36	27	AU VIRGIN-BROADBAND-AS-AP Virgin Broadband VISP Australia
75.00%	AS9386	36	27	PH DESTINY-AS-AP Destiny Inc. Philippines
73.12%	AS22047	3,318	2,426	CL VTR BANDA ANCHA S.A. Chile
70.59%	AS50648	34	24	GB UAINET-AS PE Uainet United Kingdom of Great Britain and Northern Ireland
70.39%	AS23944	1,216	856	PH SKYBB-AS-AP AS-SKYBroadband SKYCable Corporation Philippines
70.27%	AS13407	37	26	US ONECOM-CTC - One Communications Corporation United States of America
69.39%	AS41012	49	34	GB THECLOUD The Cloud Networks Limited United Kingdom of Great Britain and Northern Ireland
69.26%	AS27831	244	169	CO Colombia M?vil Colombia
68.65%	AS719	874	600	EU ELISA-AS Elisa Oyj European Union
68.42%	AS7403	38	26	CA COLBA - Colba Net Inc. Canada
67.74%	AS56055	31	21	NC MLS-NC Micro Logic Systems New Caledonia
67.74%	AS28851	31	21	CZ FORTECH-CZ Fortech s.r.o. Czech Republic
66.15%	AS197121	644	426	GR DIODOS Greek Research and Technology Network S.A Greece
65.12%	AS44034	129	84	SE HI3G Hi3G Access AB Sweden
65.00%	AS44489	200	130	CZ STARNET Starnet s.r.o. Czech Republic
64.65%	AS36907	99	64	AO TVCaboAngola Angola
63.20%	AS12912	924	584	PL ERA Polska Telefonia Cyfrowa S.A. Poland
62.69%	AS8473	67	42	SE BAHNHOF Bahnhof Internet AB Sweden
62.39%	AS34779	981	612	SI T-2-AS AS set propagated by T-2, d.o.o. Slovenia

Ranking only those ASs with more than 30 sample points in this experiment run (3,370 AS's)

And finally...

The “Mad Resolver” prize goes to the resolver:
161.185.154.2 who successfully queried for the same A RR from our server for a total of 190 times despite establishing that the DNSSEC signature was invalid after the first query!

Second prize to **82.212.62.37**, who queried the DNSKEY record for a domain 178 times

Never take NO for an answer!

Thanks guys! Great achievement!



Thank you!