Towards detecting DNSSEC validation failure with passive measurements at TLD DNS servers

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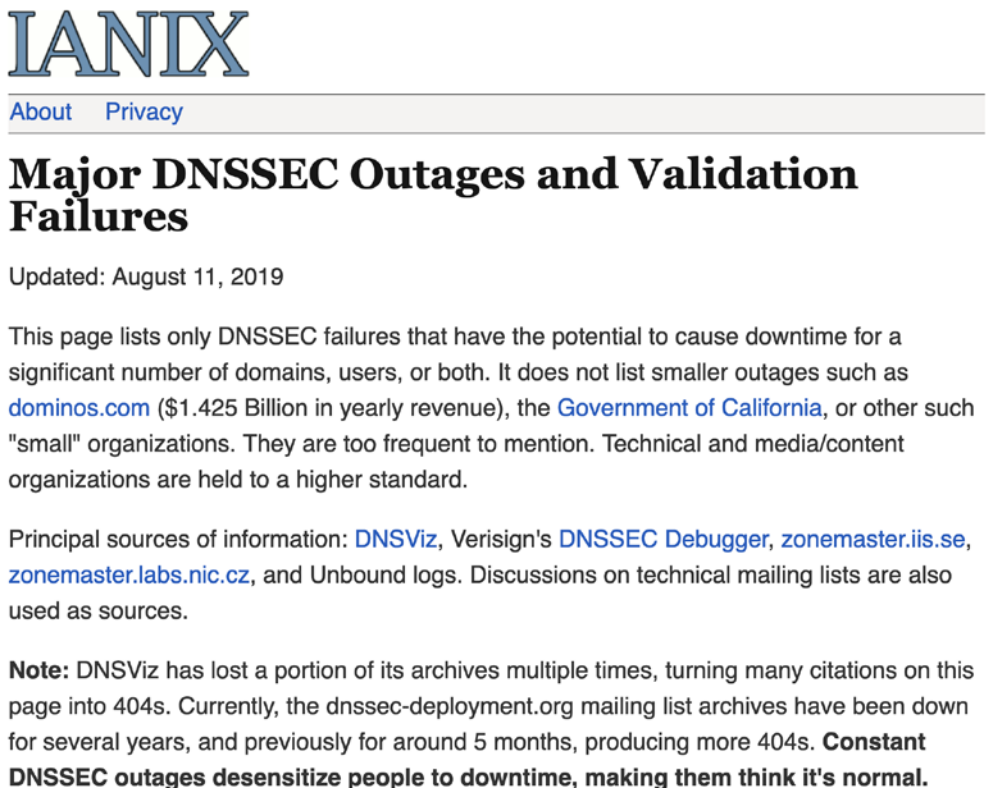
Introduction

- DNSSEC validation failure happens frequently
- Reliability of operation is a key of deployment



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About Privacy

Major DNSSEC Outages and Validation Failures

Updated: August 11, 2019

This page lists only DNSSEC failures that have the potential to cause downtime for a significant number of domains, users, or both. It does not list smaller outages such as dominos.com ($1.425 Billion in yearly revenue), the Government of California, or other such "small" organizations. They are too frequent to mention. Technical and media/content organizations are held to a higher standard.

Principal sources of information: DNSViz, Verisign's DNSSEC Debugger, zonemaster.iis.se, zonemaster.labs.nic.cz, and Unbound logs. Discussions on technical mailing lists are also used as sources.

Note: DNSViz has lost a portion of its archives multiple times, turning many citations on this page into 404s. Currently, the dnssec-deployment.org mailing list archives have been down for several years, and previously for around 5 months, producing more 404s. **Constant DNSSEC outages desensitize people to downtime, making them think it's normal.**

Research question

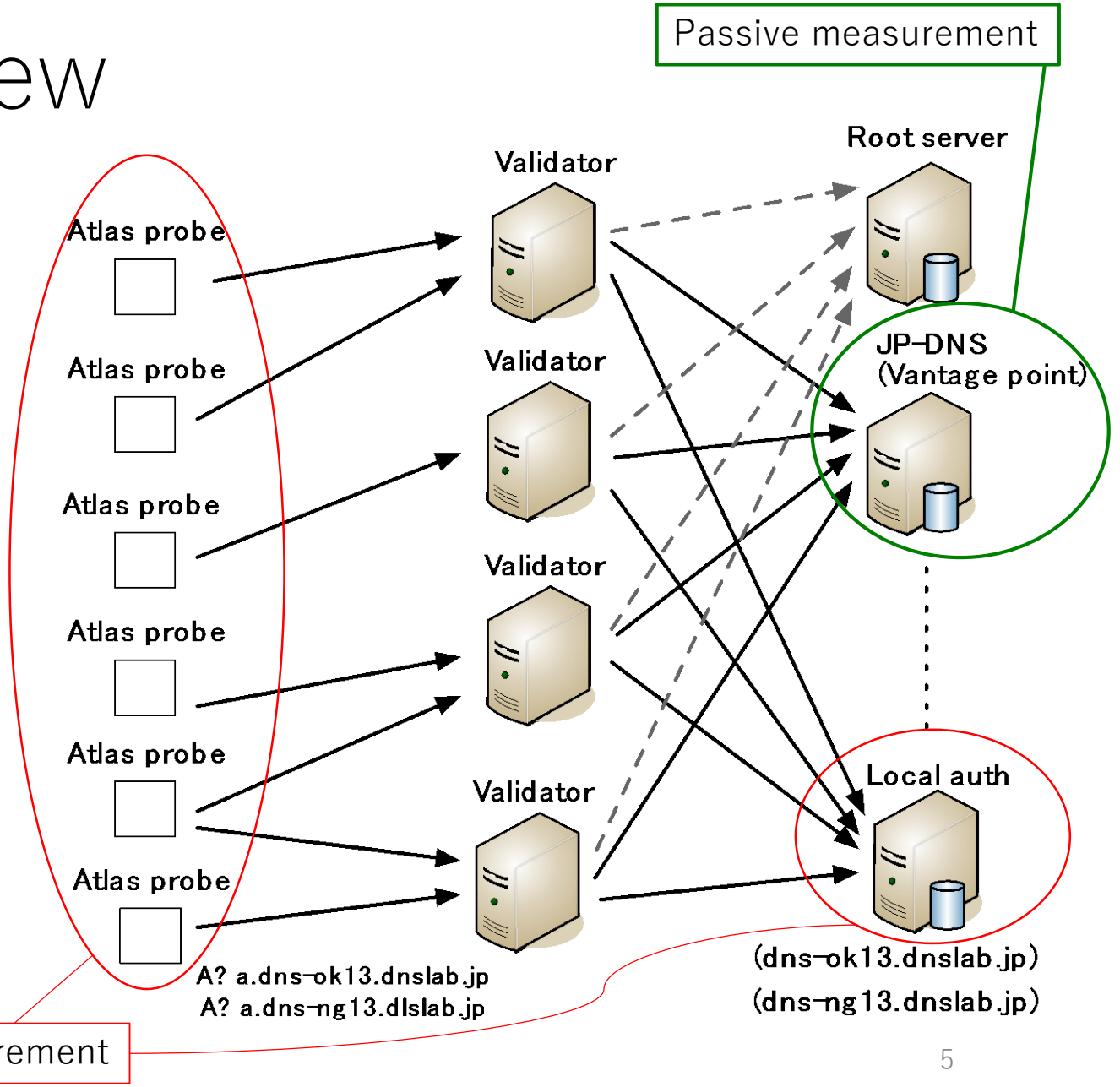
- How to detect validation failure rapidly and efficiently?
  - Active measurement
    - Periodic querying to authoritative servers
    - Higher loads for more DNSSEC available domains
  - Passive measurement
    - Change of query patterns could be a good indicator?

Towards detecting validation failures with passive measurements

- Goal:
  - Detecting change of query patterns at ccTLD servers before and after failure
- Current our work: Analysis with active measurements
  - DNS clients:
    - RIPE Atlas probe
    - DNSSEC validators (approx. 500) at ISPs or edges (not public DNS)
  - Local authoritative DNS server (3LD):
    - Successful and failed validator settings
    - Different TTL settings
  - Vantage point:
    - JP-DNS (ccTLD of JP)

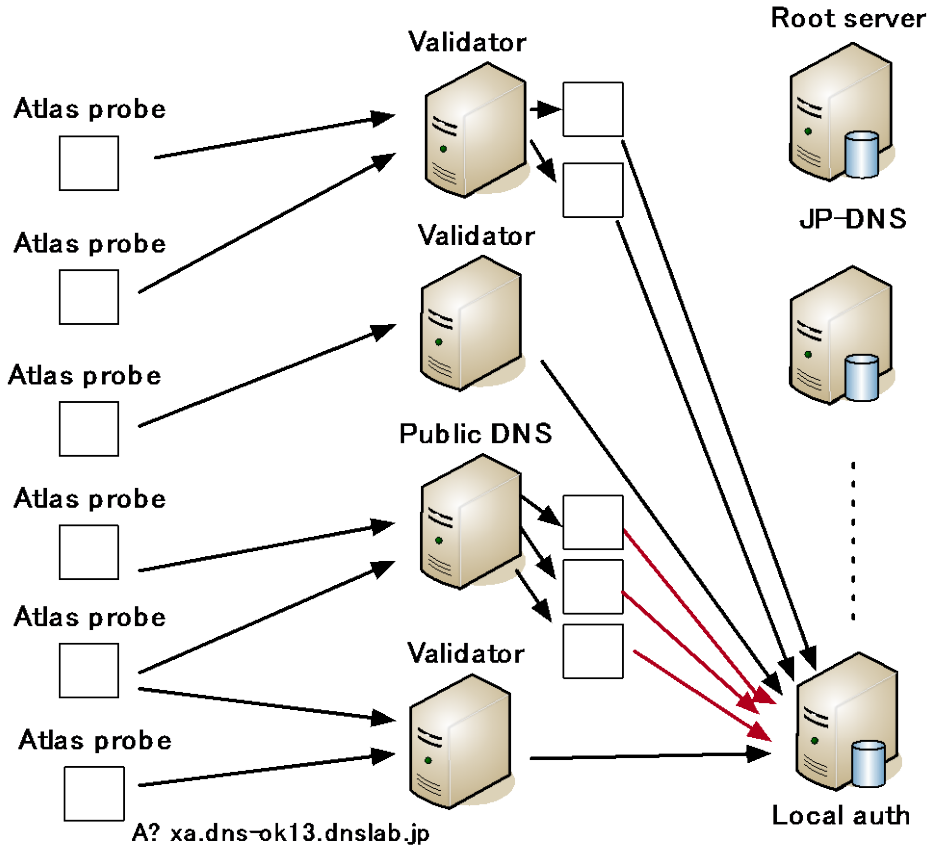
Measurement overview

- Measurement period
  - Apr 2018 (50hrs)
- Vantage point:
  - ccTLD (JP)
- Local authoritative:
  - 3LD (e.g. a.dns-ok13.dnslab.jp)
- Target queries
  - NS, A, DNSKEY, NS
- RIPE atlas probes
  - 600 DNSSEC validators at home



How to find non-public DNSSEC validators

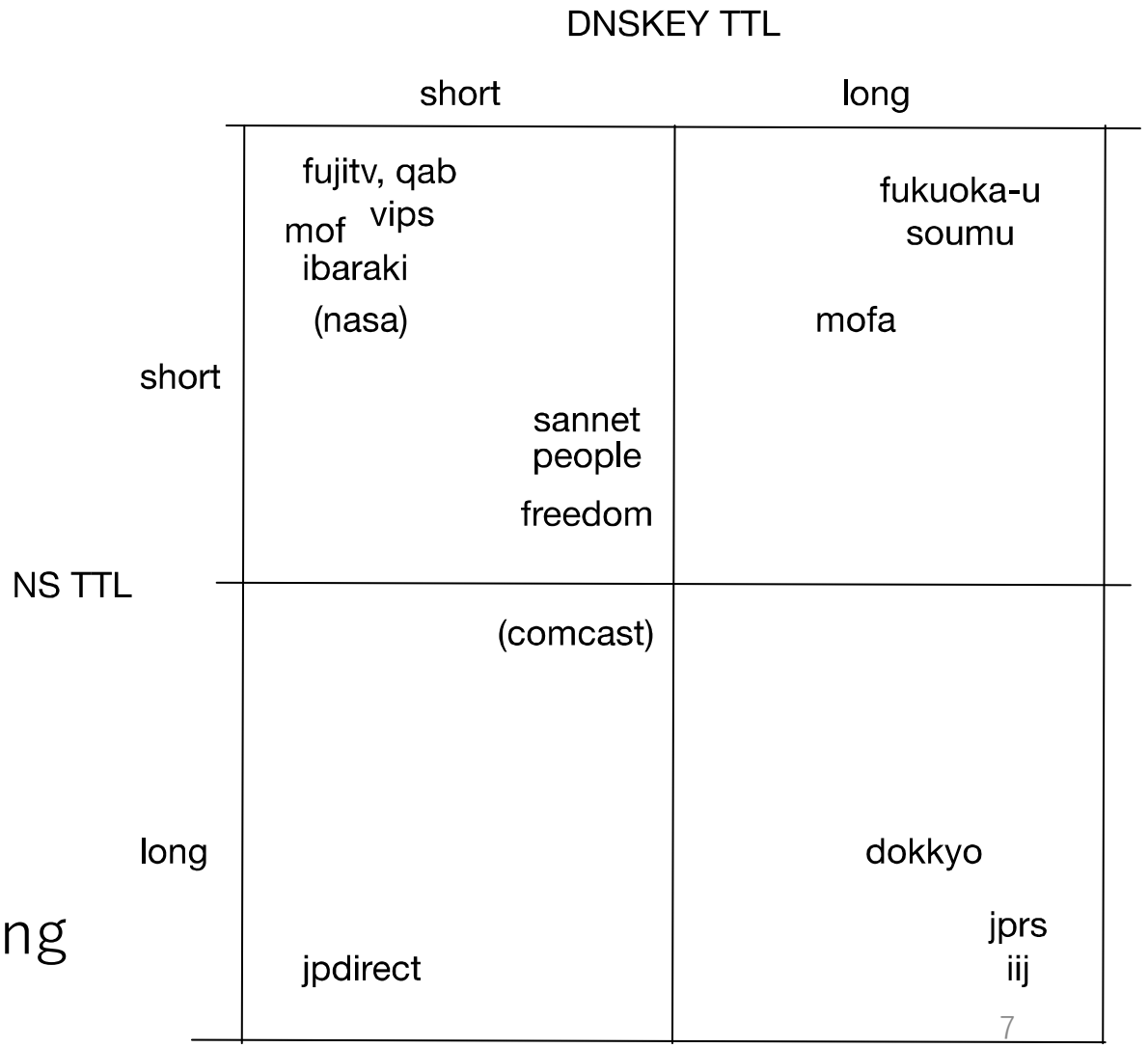
- Matching RIPE atlas probe logs to local auth logs
  - Atlas probe with home and stable-1day tags
  - Send unique A query (prepended timestamp and probe ID) with DO
  - Check query's src IP at local auth
    - E.g., ignore probes if corresponding src IPs belong to google
  - Check reply's AD flag
  - Use 602 probes and 985 resolvers



TTL parameters in JP DNSSEC domains

- NS and TTL settings
  - NS short and DNSKEY short
    - Media sites
  - NS long and DNSKEY long
    - ISP, registry
  - NS middle and DNSKEY middle
    - ISPs
  - NS short and DNSKEY long
    - government

No clear recommendations on each setting



Parameter settings

Name	Valid	TTL				Interval	Duration
		NS	DKEY	DS	A		
ok13	y	600	600	7200	600	540	8100
ok23	y	600	7200	7200	600	540	8100
ok33	y	7200	600	7200	600	540	8100
ok43	y	7200	7200	7200	600	540	8100
ng13	n	600	600	7200	600	540	8100
ng23	n	600	7200	7200	600	540	8100
ng33	n	7200	600	7200	600	540	8100
ng43	n	7200	7200	7200	600	540	8100

- Valid: successful validator (y) and failed validator (n)
- Interval: query interval from each probe
- Duration: measurement period for each probe

Parameter settings

DS and A are fixed
Interval and duration are also fixed

Successful validators

Failed validators

Name	Valid	TTL				Interval	Duration
		NS	DKEY	DS	A		
ok13	y	600	600	7200	600	540	8100
ok23	y	600	7200	7200	600	540	8100
ok33	y	7200	600	7200	600	540	8100
ok43	y	7200	7200	7200	600	540	8100
ng13	n	600	600	7200	600	540	8100
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ng43	n	7200	7200	7200	600	540	8100

- Valid: successful validator (y) and failed validator (n)
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Results: Queries at local authoritative

name	All	A	DKEY	DS	NS
ok13	16003	6777	5512	2705	745
ok23	12938	6973	2117	2834	767
ok33	16018	6841	5675	2858	370
ok43	11424	6469	2003	2622	188

Successful

name	All	A	DKEY	DS	NS
ng13	64439	14929	38319	7781	2688
ng23	63847	15292	37017	8012	2743
ng33	62805	14661	37161	7841	2397
ng43	61283	14755	35488	7785	2471

Failed

- Overall queries increased in failure (as expected)
  - Due to negative cache
  - All 5x, A 2x, DKEY 7x, DS 3x, NS 6x
- TTL settings for NS and DNSKEY worked in successful validator

Queries at ccTLD (JP-DNS)

name	All	A	DKEY	DS	NS
ok13	1456	1305	61	87	2
ok23	1816	1705	14	91	1
ok33	1415	1268	39	101	0
ok43	1285	1171	12	99	0

Successful

name	All	A	DKEY	DS	NS
ng13	2342	2081	136	114	1
ng23	1958	1777	71	105	1
ng33	1594	1372	105	110	1
ng43	1468	1279	81	104	1

Failed

- Still queries increased, but not so significant
  - DNSKEY is a better indicator than DS
  - Longer DNSKEY TTL is better (due to negative cache?)

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Attenuation at ccTLD

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Local authoritative

name	All	A	DKEY	DS	NS
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ng23	1958	1777	71	105	1
ng33	1594	1372	105	110	1
ng43	1468	1279	81	104	1

ccTLD (JP-DNS)

- Huge attenuation of observable queries
  - All 30x, A 7x, DNSKEY 300x, DS 200x
- A validation failure in minor domains is likely difficult to detect

Conclusion

- We conducted DNS passive and active measurement to know query behaviors in DNSSEC failure
  - Active: RIPE Atlas probes
  - Passive: ccTLD (jp) and local authoritative
- DNS queries increased at DNSSEC validation failure
  - Attenuation of queries in DNS hierarchy
  - DNSKEY difference is still a good metric to detect validation failure
  - DS is not so significant

Future work

- Further large-scale studies required
  - Difference in public and other resolvers
  - Quantify ccTLD, 2LD, and 3LD attenuation
  - TTL effects in failure
  - Longitudinal analysis of a part of JP-DNS servers' traces
  - Effective (quasi-)realtime detection method at TLD servers' side