Finding DNSSEC Validators with Check-Repeat

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Joint Work

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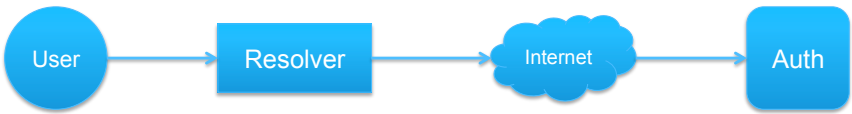
Why Count Validators

- DNSSEC suffers somewhat from the “chicken-and-egg problem.”
- The publication-side of DNSSEC is well studied. The consumer-side, not so much.
- Surveys and estimates of validator population inform the upcoming root KSK rollover (2015).

Enumerating Validating Resolvers is Hard

- Resolver chaining
- Multiple resolvers per user
- Multiple IPs per resolver
- NATs
- Dynamic addressing
- Unexpected query behavior
- Trust Anchor configuration not conveyed in queries

Simplistic Model



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Chaining

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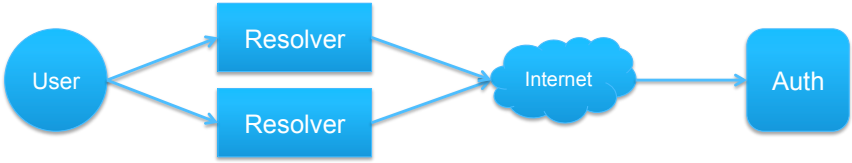
Multiple Resolvers per User



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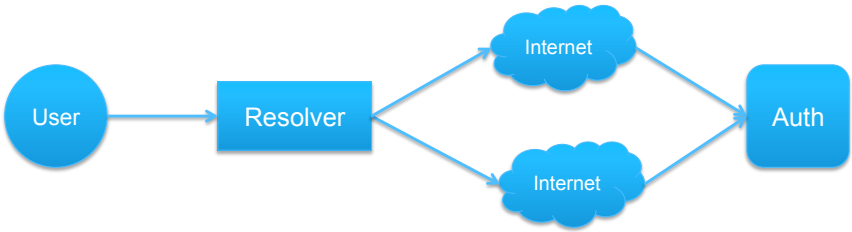
Multiple IPs per Resolver



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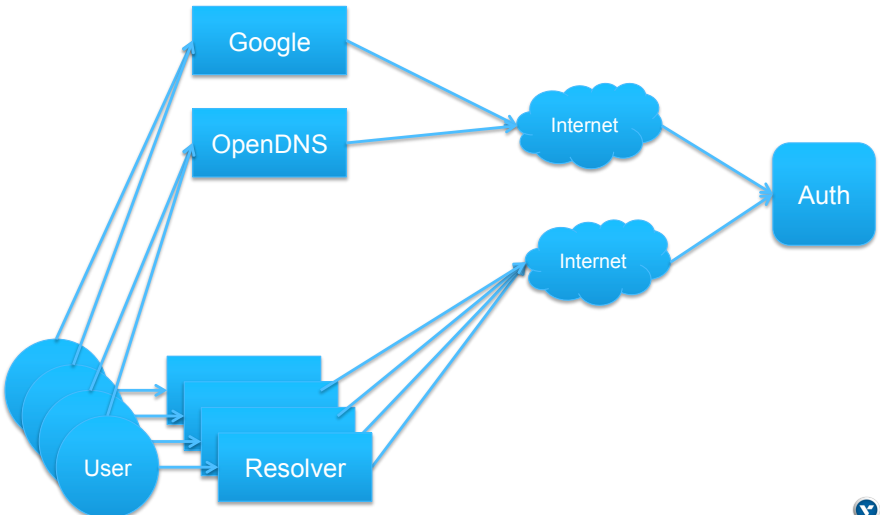
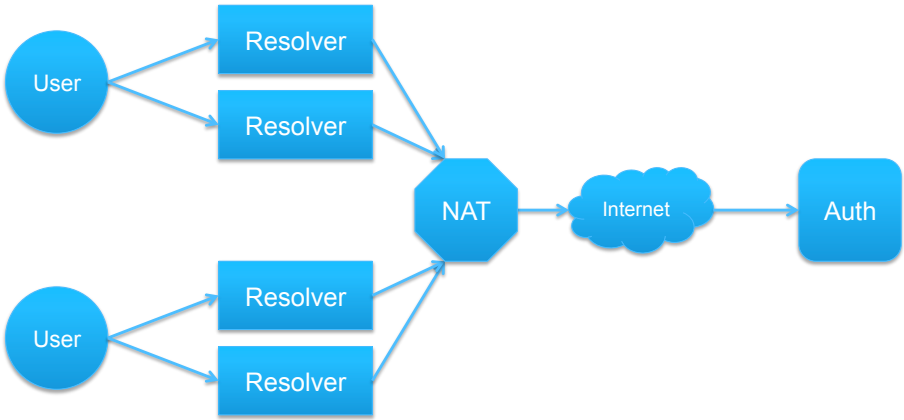
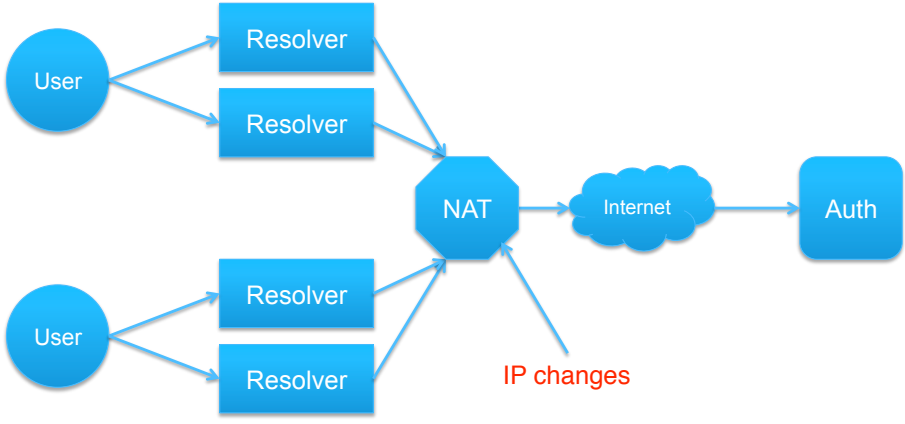
Public Resolvers



NATs


User
Resolver
Resolver
User
Resolver
Resolver
NAT
Internet
Auth

Dynamic Addressing



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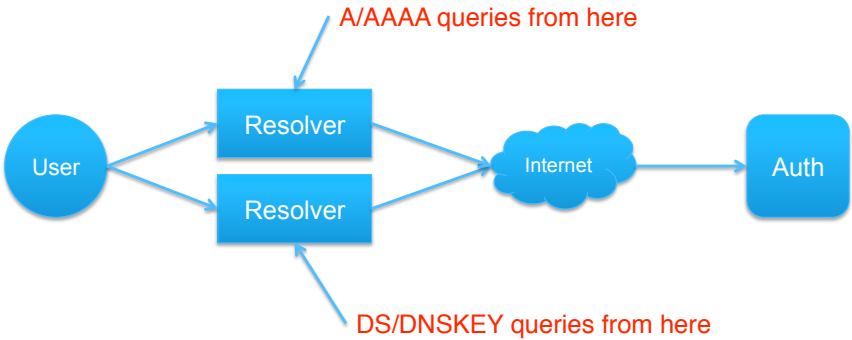
Unexpected Query Behavior



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Previous Approaches

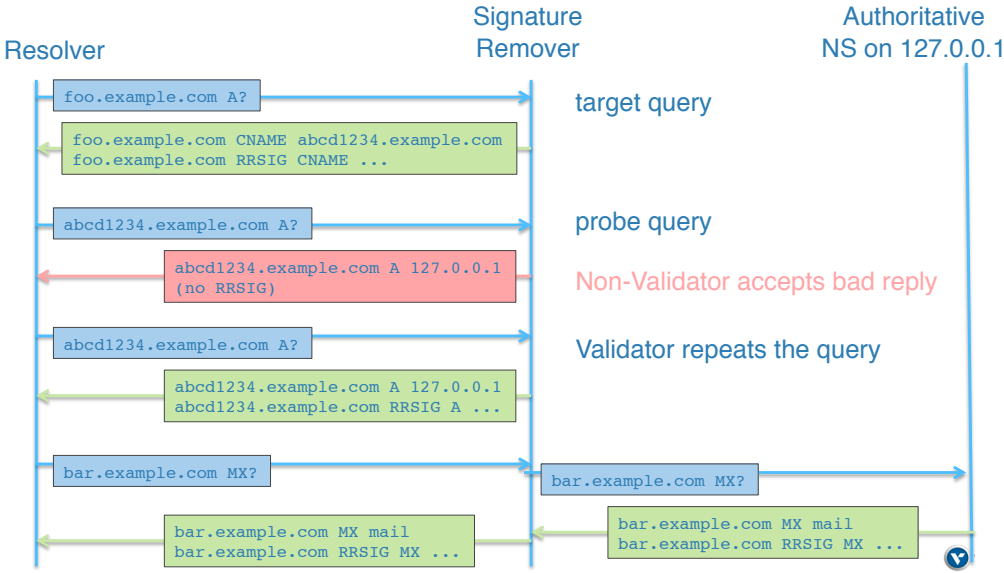
- Look for DNSKEY and DS queries at authoritative name servers.
  - Assumption that only validating resolvers make DNSKEY/DS queries might not be true.
- Correlate DNS/HTTP requests for pairs of DNS names. Lack of use of improperly signed name implies validation.
  - Web browser bias?
  - Good for measuring end user adoption
  - Could measure application-based validation, vs resolver-based.

Check-Repeat

- When presented with an improperly signed DNSSEC response, most validating resolver implementations will retry the query.
  - At least once.
  - To another authoritative name server.

- However…
  - Query retries look a lot like packet loss.
  - Not all implementations retry.
  - Doesn't work for "chained" resolvers.

Signature Remover



How to attract DNS queries?

- A web bug via DNS prefetching.

```
<link rel="prefetch" href="http://prefetch.validatorsearch.verisignlabs.com" />

<a href="http://prefetch.validatorsearch.verisignlabs.com"></a>
```

- Take advantage of popular, yet non-critical domains.

wpad.{com,net,org,us,biz}

- “Web Proxy Auto Discovery”
- Work by Microsoft and others, documented as Internet-Draft but never RFC.
- HTTP agents (browsers) try to load URLs by prepending “wpad” to their local domain:

  `http://wpad.cs.ucla.edu/wpad.dat`
- On failure, try again by removing domain labels:

  `http://wpad.ucla.edu/wpad.dat`

  `http://wpad.edu/wpad.dat` ?

  `http://wpad/wpad.dat` ?

Results

Indicators of Validation

- DS/DNSKEY queries
- Repeats
- Consistent pattern over time

Nominum/Vantio

- Nominum's resolver product, Vantio, does not consistently retry signature-removed queries.
- Fortunately, Vantio openly answers "version.bind" queries by default.
- Whitelisted for this study.

Trace-I

Totals	
Days	36
Queries	24,786,845
Trials	6,498,277

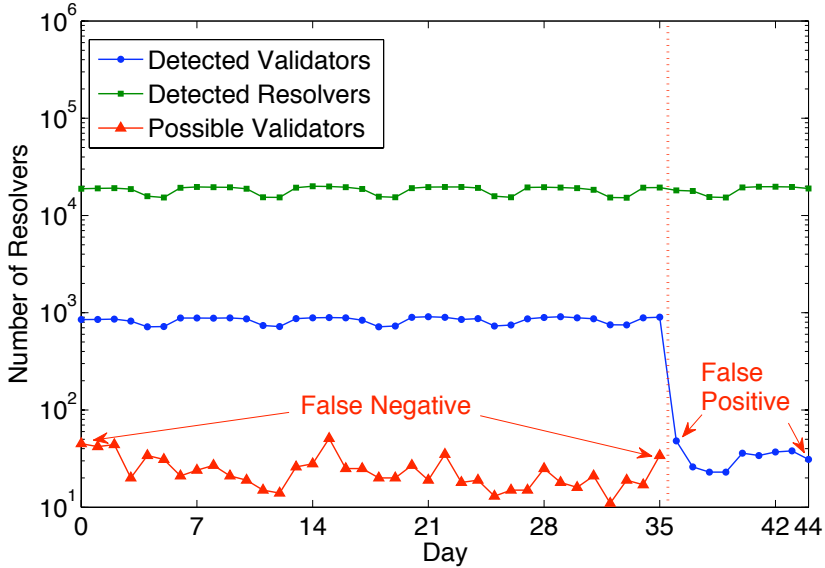
Daily Averages	
IPs	24,143
Resolvers	18,224
Validators	836
%Validating	4.6%

Quantifying False Positives

- Queries repeated due to packet loss could be misinterpreted as validations.
- Signature remover disabled for 9 days to find false positives.

Daily Averages	
IPs	24,522
Resolvers	18,247
Validators	33
False Positives	0.18%

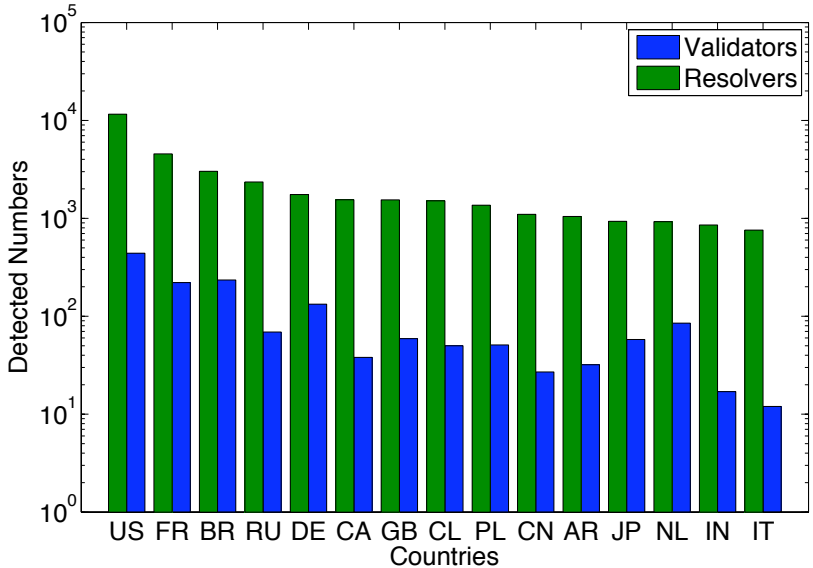
Number of Resolvers and Validators Measured



Quantifying False Negatives

- Cases where resolver received DNSKEYs, signatures were removed, but did not see repeated query.
- Likely caused by multi-level caching, a.k.a. DNS forwarding.
- About 30 false negatives out of 20,000 resolvers daily.
- False negative rate 0.15%.

Geographic Distribution of Validating Resolvers



Did we find all Resolvers on the Internet?

- Compared resolvers observed by Check-Repeat to those seen by G.GTLD-SERVERS.NET (one of 13 COM/NET name servers).
- Check-Repeat sees 1.6% of resolvers seen by G.GTLD.
- But 63.5% of all responses from G.GTLD go to Check-Repeat resolvers.
- At least 12.3% of all responses from G.GTLD go to DNSSEC validators.

Comparison with Previous Work

- [2010] Gudmundsson and Crocker found 10% (upper limit) of queries to ORG name servers are from resolvers that ask for DNSKEY/DS.
  - We find 12.3% for COM/NET (lower limit)
- [2012] Wander and Weis report 4.8% of *trials* indicate validation.
- [2012] Huston reports 9% of Internet *end users* have validating resolvers and 4% of resolvers validate.
  - 7 days of data
- [2012] Huston later revises and reports 1.6% of *end users* and 1.7% of *resolvers* perform validation.
  - 17 days of data
  - We find 4.6% (of resolvers)

Thank You

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