DNS as a Defense Tool

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Abstract

At the heart of Internet connectivity, the Domain Name System has for three decades been the Internet's transmission of growth. New applications like the web were only loosely imagined in the early days, but have become successful because the Internet allows almost anyone to add almost anything -- and DNS is what makes that possible.

In the 15 years since commercialization and privatization, the world's economy has become enmeshed with the Internet, and as a result, almost all crime and misbehaviour in the world today is now linked to the Internet in some way. These trends coalesced, and it is now possible to investigate and prevent Internet-linked crime by studying and using the DNS itself, which is the map of the Internet's territory.

In this lecture, Dr. Paul Vixie, CEO of Farsight Security, will describe: DNS itself; ways DNS can be abused to commit or facilitate crime; and, ways DNS can be used to detect, prevent, and investigate crime. Farsight Security's passive DNS system including the DNSDB database is used worldwide by business, law enforcement, and the academic community, and will be broadly demonstrated.

DNS Itself

Internet as Territory

- But what **is** the internet?
  - “It's the largest equivalence class in the reflexive transitive symmetric closure of the relationship *can be reached by an IP packet from.”*
    - (Seth Breidbart)
- IP addresses, IP packets, underlie everything
- We overlay IP with many things, e.g., *the web*
- Most important overlay (for security) is: DNS

DNS as Map

- Most everything we do on the Internet…
  - B2C Web, B2B Web, E-mail, I-M, <*your idea here*>
  - …relies on TCP/IP, and begins with a DNS lookup
- Mobile Internet is dominated by search…
  - …but search itself relies extensively upon DNS
- DNS has a rigorous internal structure
  - Things that are in fact related, *are* related in DNS
  - You can have *whois* privacy, but not DNS privacy

Criminal DNS

- The Internet has been a great accelerator of human civilization
  - Inevitably, this includes human crime
- Online crime is impossible without DNS
  - Cheap throw-away domain names
  - DNS registrars and servers in bad neighborhoods
  - *Whois* privacy or simply bad *whois* data
- *Nature, to be commanded, must be obeyed*.
  - (Francis Bacon)

So, About that Internal Structure

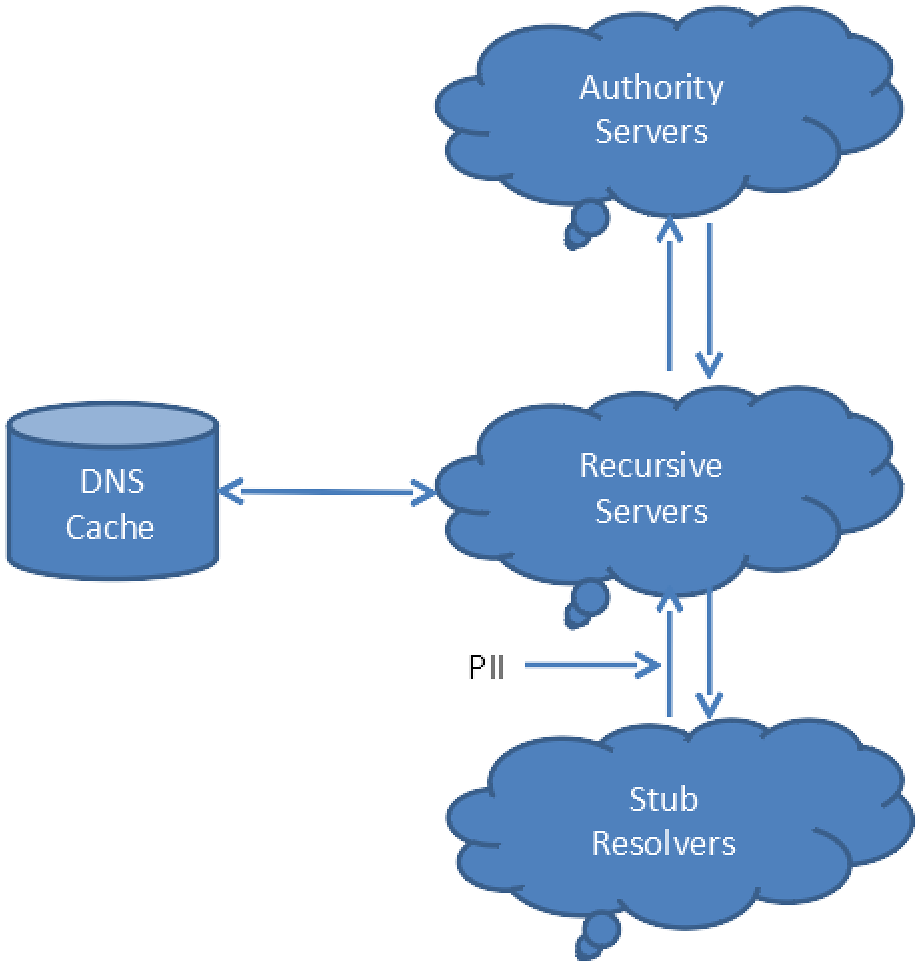
- Domain names are grouped into *zones*
  - Like *root* zone, or “`COM`”, or “`EXAMPLE.COM`”
- A *zone* has one or more *name servers*
  - Like “`COM. NS a.gtld-servers.net.`”
- Each *name server* has one or more *addresses*
  - Like “`a.gtld-servers.net. A 192.5.6.30`”
- Other domain names also have *addresses*
  - Like “`www.apnic.net. A 203.119.102.244`”
- IP *addresses* are grouped into *netblocks*
  - Like “`192.5.6.0/24`” or “`203.119.102.240/28`”

DNS Security Features

- TSIG secures heavy weight transactions
  - Like UPDATE, IXFR/AXFR; but not QUERY
- DNSSEC secures data end-to-end
  - Zone is signed; responses contain signatures
  - Zone has keys; these are signed in parent zone
  - QUERY initiator can validate signatures
  - Requires universally trusted *root signing key*
- Use TSIG and DNSSEC: they work & they'll help
  - But: our actual topic today lies elsewhere

DNS As Abused

DNS Data Flow

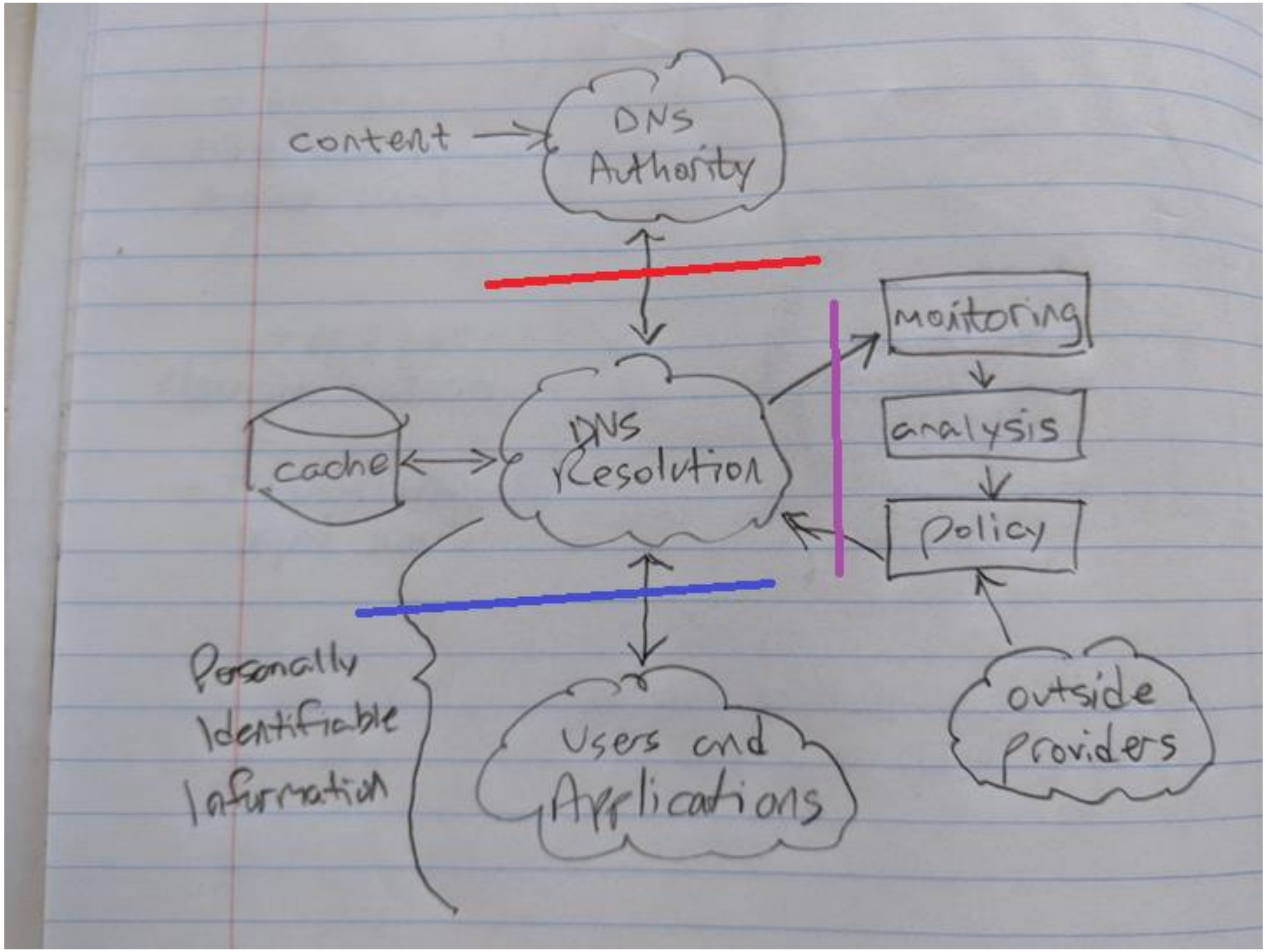


13 root servers,
~250 Cctld's,
~15 old Gtld's,
~2000 new Gtld's,
~500M 2LD/etc

Campus,
Enterprise,
OpenDNS,
GoogleDNS,
IBM, CloudFlare

Servers, Laptops,
Smartphones,
IoT, other devices

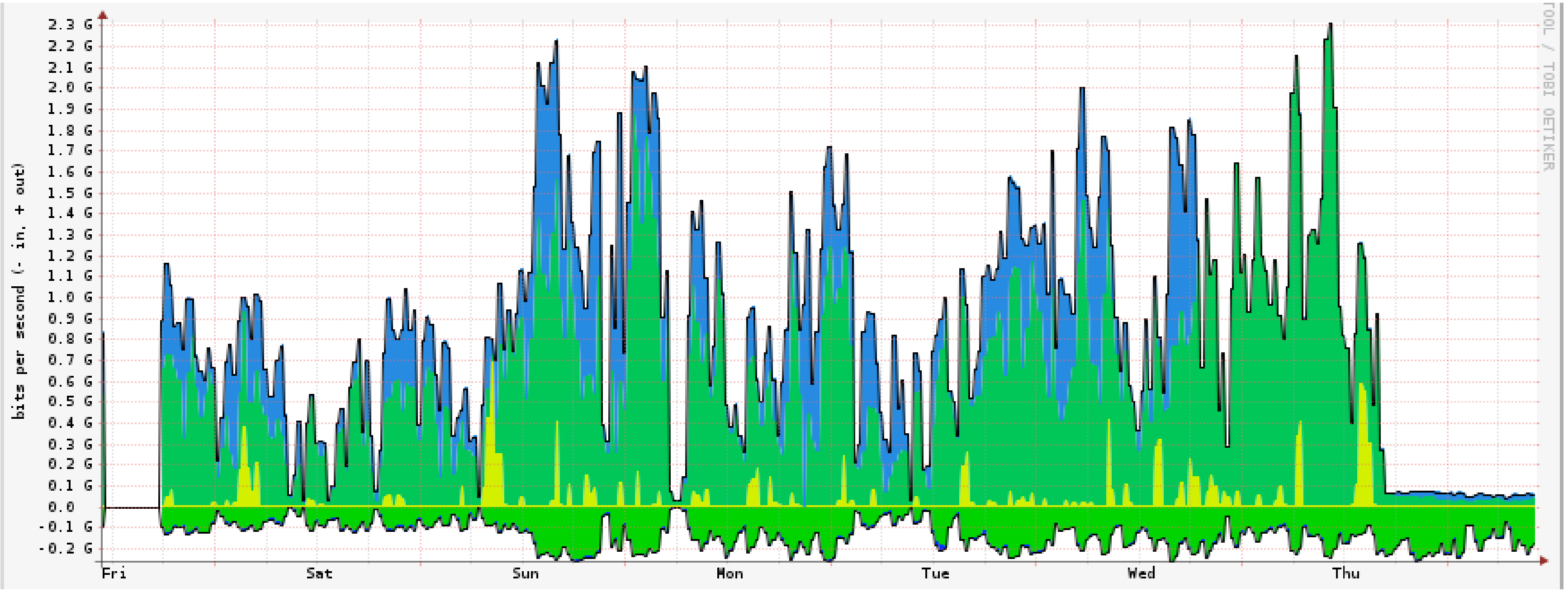
How Farsight Sees DNS



DNS Response Rate Limiting (RRL)

- If you run a DNS content (“authority”) server, it has to be massively overprovisioned
- Because OPN’s don’t have SAV, your server is a purpose-built DNS DDoS reflecting amplifier
- BIND, NSD, Knot now support DNS RRL, which accurately guesses what’s safe to drop
- Your authority servers need this, whereas your recursive servers need to be firewalled off

RRL In Action: Afilias



“…too cheap to meter”

- SpamAssassin as a teaching tool
    - For example: dotted quads in body as spamsign
- RRP and EPP: solving “the .COM problem”
    - Running a race to the bottom (cheaper; sooner)
- Quantity and fluidity having only one purpose
    - 30 seconds? Really?
- Fitting Sturgeon’s revelation
    - “90% of <thing> is crap”

Takedown: Far End Tactics

- Since we can’t prevent it…
  - …we’ll have to evolve coping strategies
- Takedown as a Service (TaaS?)
  - Yes, you can outsource this now
- A new profit center! (.TK)
  - “Kill all you want, we’ll make more!”
- Whack-a-mole as a Service (WaaS?)
  - Incrementalism breeds better criminals

Firewalls: Near End Tactics

- If we can’t prevent it and takedown is hard…
  - …then we’ll have to fight them at our doorstep
- We can filter IP+port, URL, and now even DNS
  - But, bad guys are endlessly adaptive
  - Ergo, so must we be
- We can’t afford manual configuration
  - So, firewall config now follows a pub-sub model

DNS Firewalls with RPZ

- Uses DNS zones to carry DNS Firewall policy
  - R-P-Z = Response Policy Zones
- Pub-sub is handled by NOTIFY/TSIG/IXFR
  - Many publishers, many subscribers, one format
- Subscribe to multiple external feeds
  - And create your own, for local policy reasons
- Simple failure or walled garden, as you choose
  - We call this “taking back the DNS”

RPZ Capabilities

- Triggers (RR owners):
  - If the query name is $X
  - If the response contains an address in CIDR $X
  - If any NS name is $X
  - If any NS address is in CIDR $X
  - If the query source address is in CIDR $X

- Actions (RR data):
  - Synthesize NXDOMAIN
  - Synthesize CNAME
  - Synthesize NODATA
  - Synthesize an answer
  - Answer with the truth

Why Use RPZ?

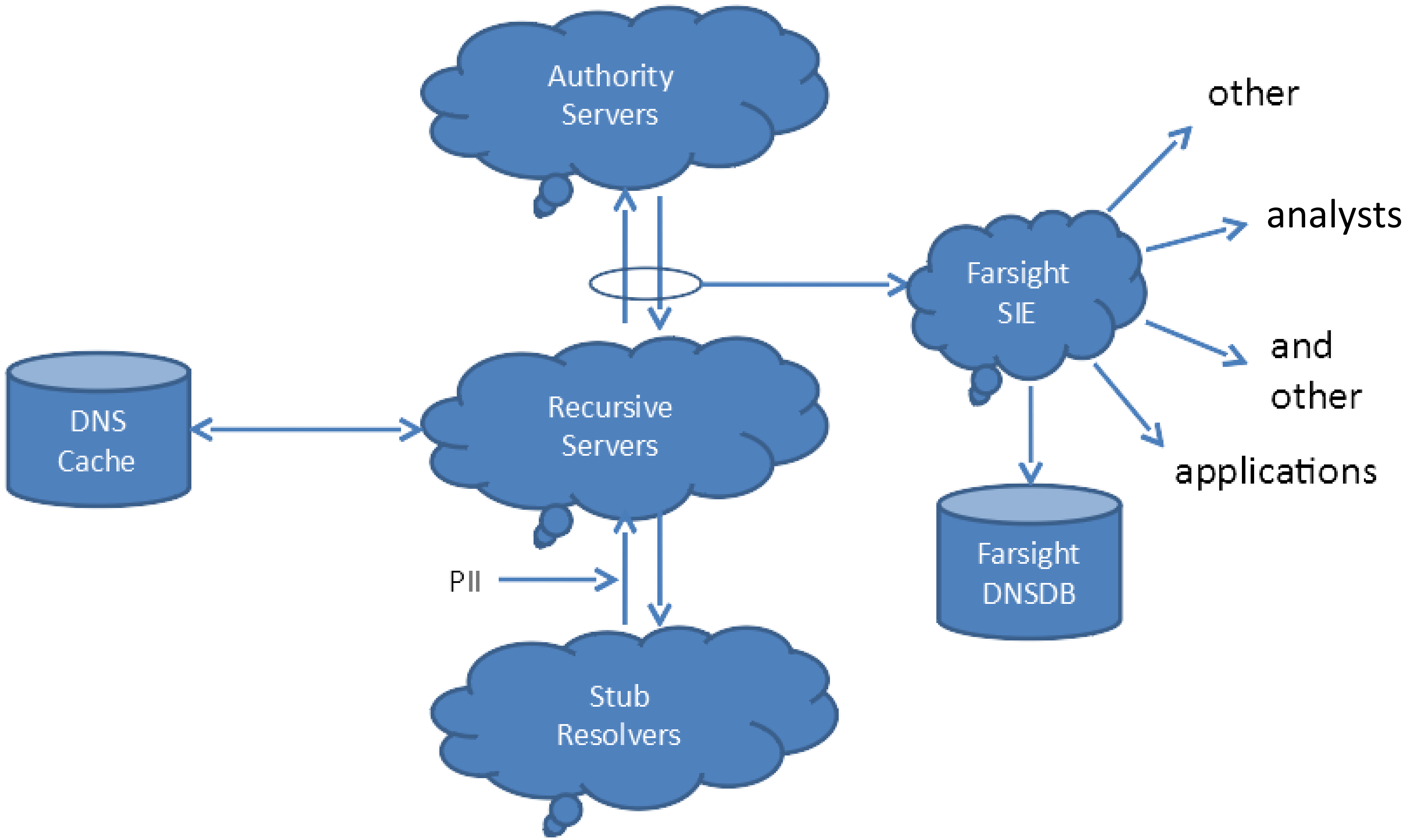
- Easy stuff:
  - Block access to DGA C&C’s
  - Block access to known phish/driveby
  - Block e-mail if envelope/header is spammy
- More interesting stuff:
  - Block DNS A/AAAA records in bad address space
    - E.g., import Cymru Bogons or Spamhaus DROP list
  - Block domains having some computable attribute
    - E.g., Farsight Newly Observed Domains (NOD) list

Key RPZ Takeaways

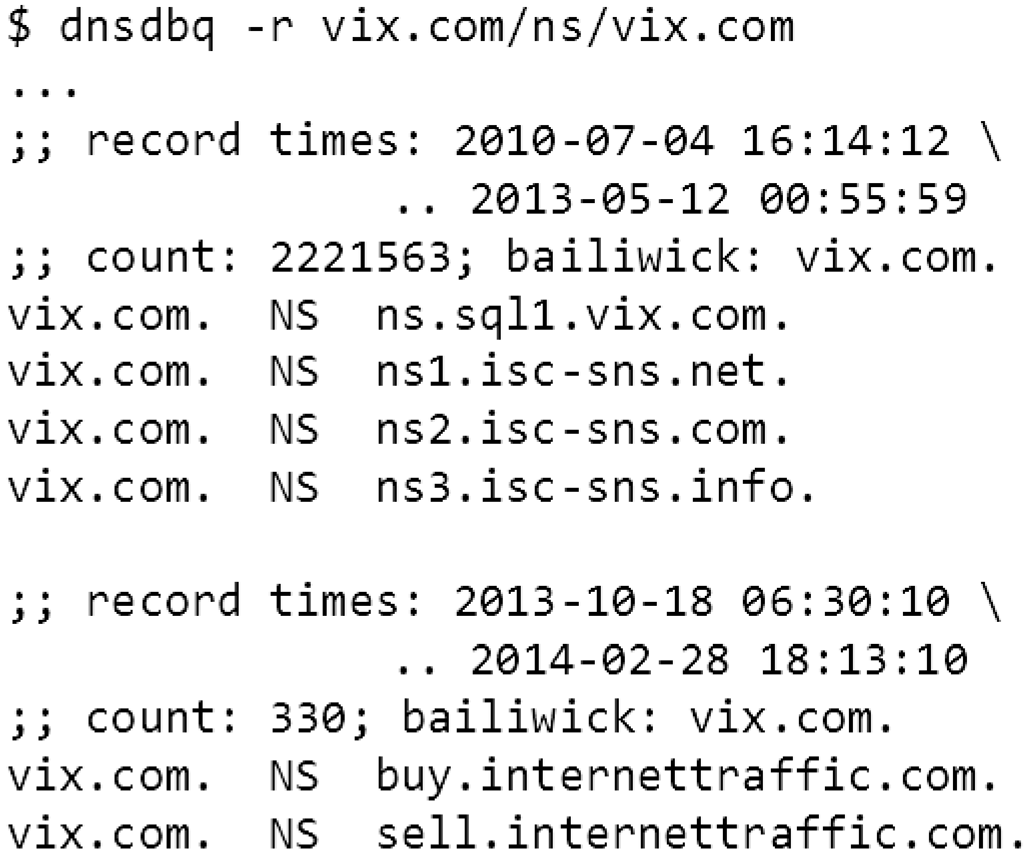
- Implications:
    - Open market for producers and consumers
    - Differentiated service at a global scale
    - Instantaneous wide area takedown
- Deployment:
    - The RPZ standard is open and unencumbered
    - So far implemented in BIND, Unbound, PowerDNS
    - BIND RPZ performance is not unreasonable (~5% QPS loss)
    - New RPZ features will be backward compatible
    - RPZ is not an IETF standard

DNS As Observed

Passive DNS Data Path

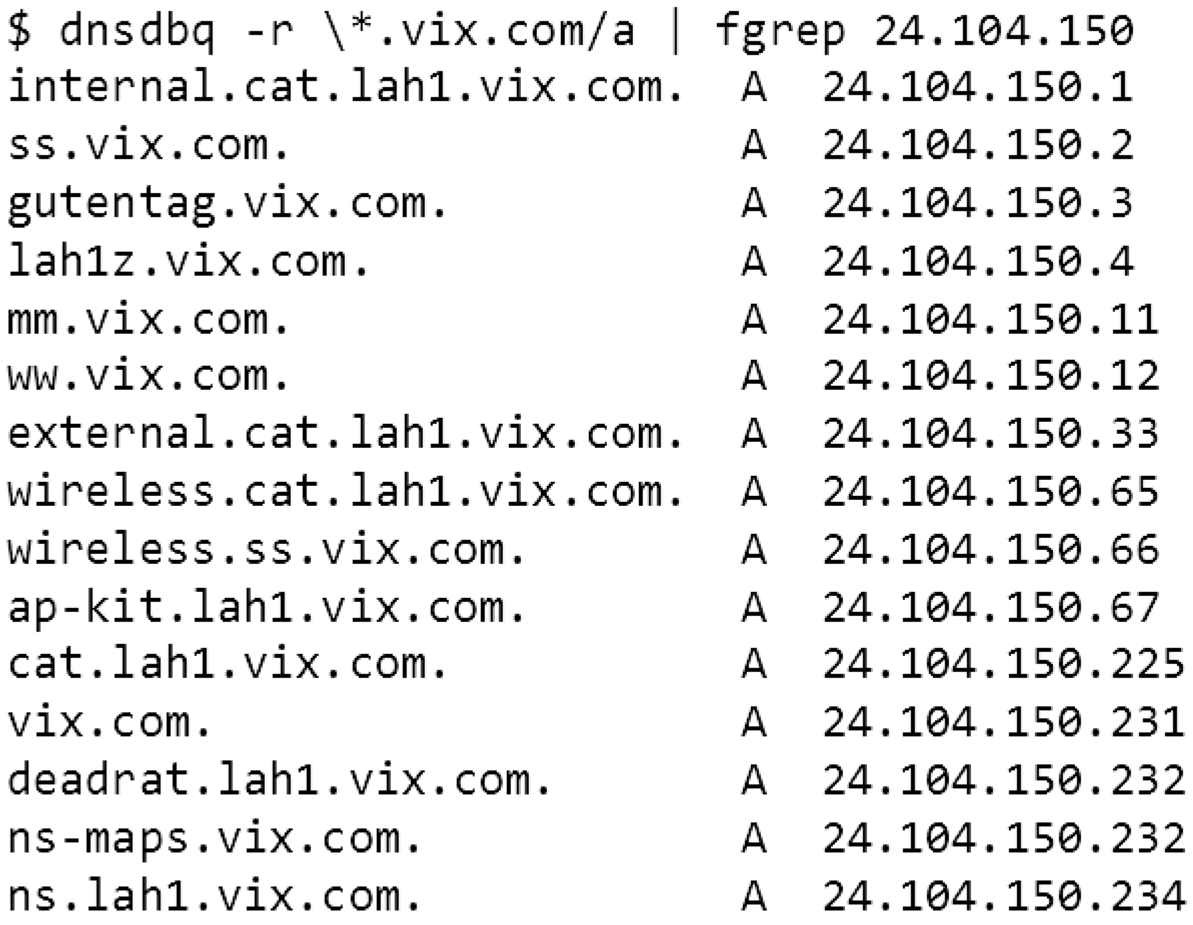


Owner Lookup, Show History



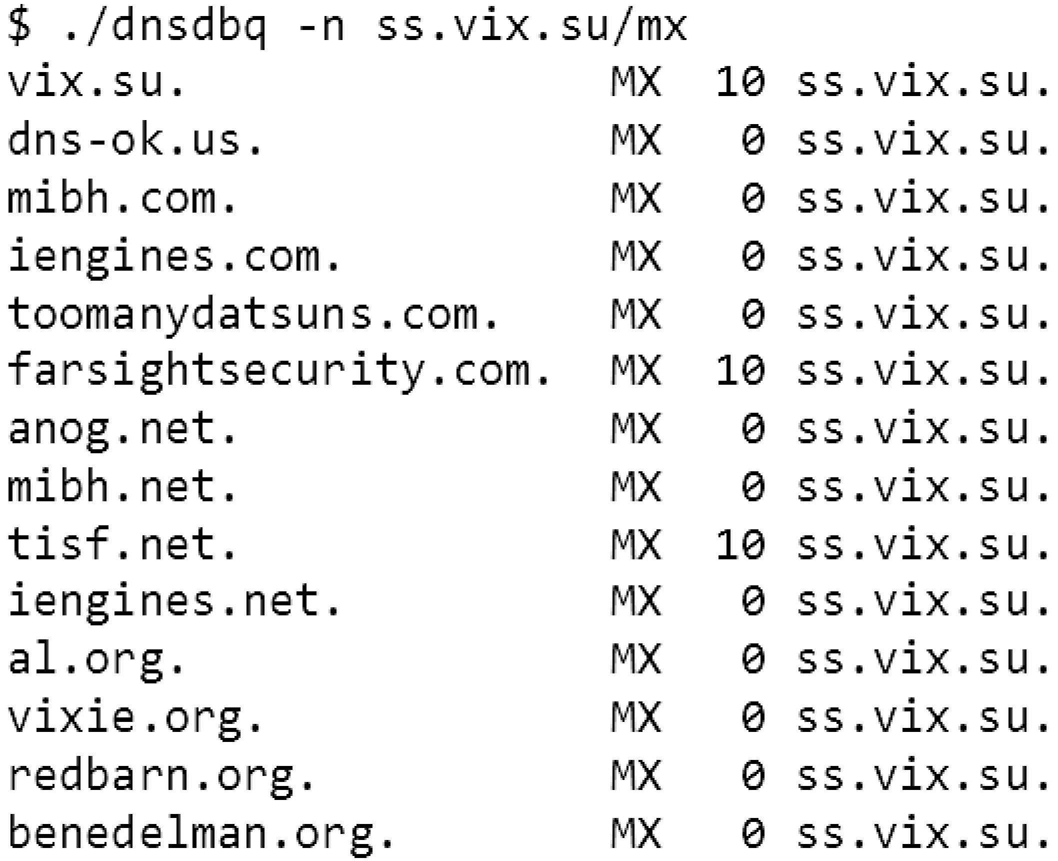
```
$ dnsdbq -r vix.com/ns/vix.com
...
;; record times: 2010-07-04 16:14:12 \
               .. 2013-05-12 00:55:59
;; count: 2221563; bailiwick: vix.com.
vix.com.  NS  ns.sql1.vix.com.
vix.com.  NS  ns1.isc-sns.net.
vix.com.  NS  ns2.isc-sns.com.
vix.com.  NS  ns3.isc-sns.info.

;; record times: 2013-10-18 06:30:10 \
               .. 2014-02-28 18:13:10
;; count: 330; bailiwick: vix.com.
vix.com.  NS  buy.internettraffic.com.
vix.com.  NS  sell.internettraffic.com.
```

Owner Wildcards (left or right side)



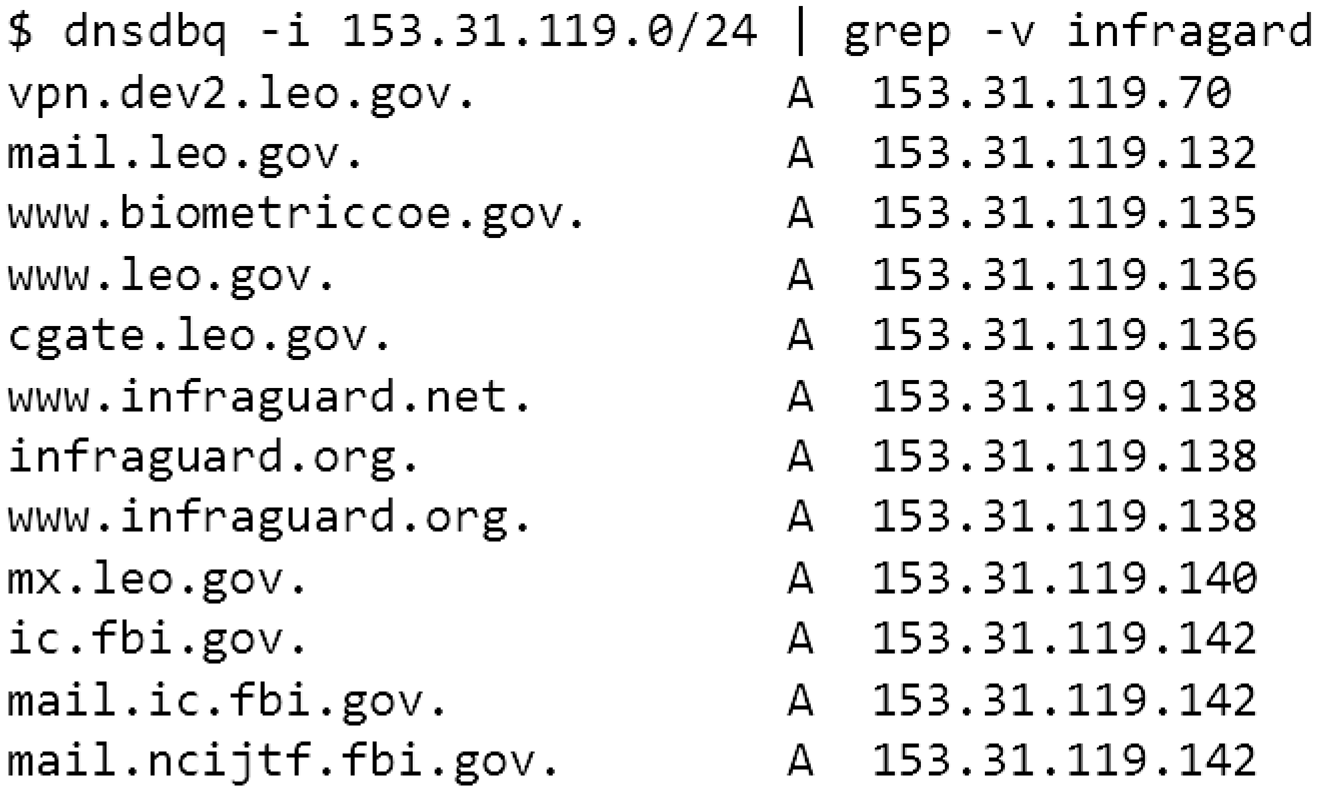
```
$ dnsdbq -r \*.vix.com/a | fgrep 24.104.150
internal.cat.lah1.vix.com.  A  24.104.150.1
ss.vix.com.                 A  24.104.150.2
gutentag.vix.com.           A  24.104.150.3
lah1z.vix.com.              A  24.104.150.4
mm.vix.com.                 A  24.104.150.11
ww.vix.com.                 A  24.104.150.12
external.cat.lah1.vix.com.  A  24.104.150.33
wireless.cat.lah1.vix.com.  A  24.104.150.65
wireless.ss.vix.com.        A  24.104.150.66
ap-kit.lah1.vix.com.        A  24.104.150.67
cat.lah1.vix.com.           A  24.104.150.225
vix.com.                    A  24.104.150.231
deadrat.lah1.vix.com.       A  24.104.150.232
ns-maps.vix.com.            A  24.104.150.232
ns.lah1.vix.com.            A  24.104.150.234
```

Data Lookup, By Name



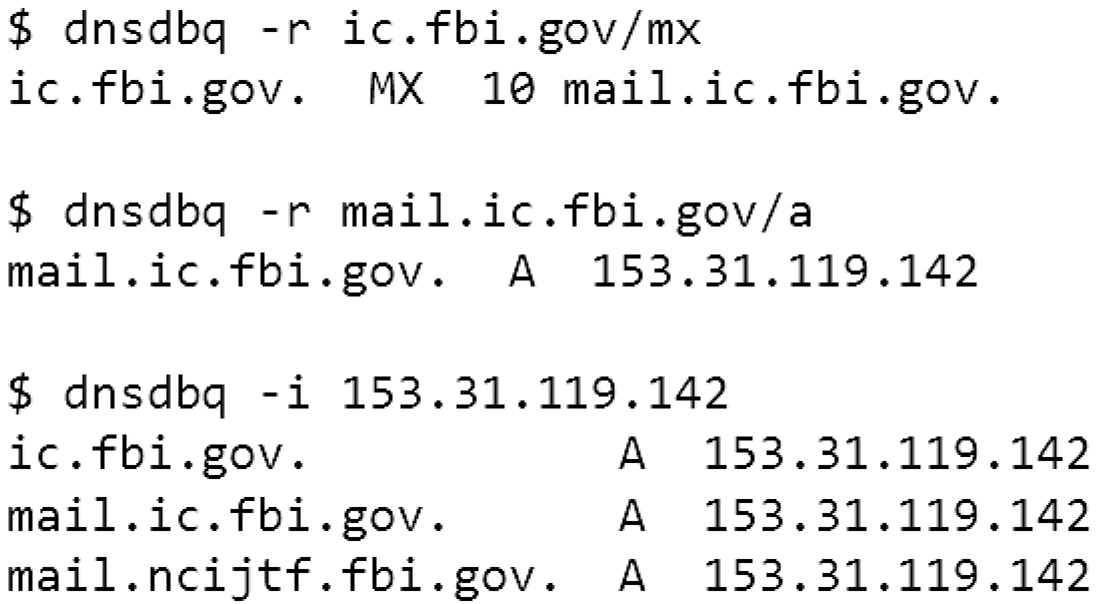
```
$ ./dnsdbq -n ss.vix.su/mx
vix.su.                MX  10 ss.vix.su.
dns-ok.us.             MX   0 ss.vix.su.
mibh.com.              MX   0 ss.vix.su.
iengines.com.          MX   0 ss.vix.su.
toomanydatsuns.com.    MX   0 ss.vix.su.
farsightsecurity.com.  MX  10 ss.vix.su.
anog.net.              MX   0 ss.vix.su.
mibh.net.              MX   0 ss.vix.su.
tisf.net.              MX  10 ss.vix.su.
iengines.net.          MX   0 ss.vix.su.
al.org.                MX   0 ss.vix.su.
vixie.org.             MX   0 ss.vix.su.
redbarn.org.           MX   0 ss.vix.su.
benedelman.org.        MX   0 ss.vix.su.
```

Data Lookup, by IP Address Block



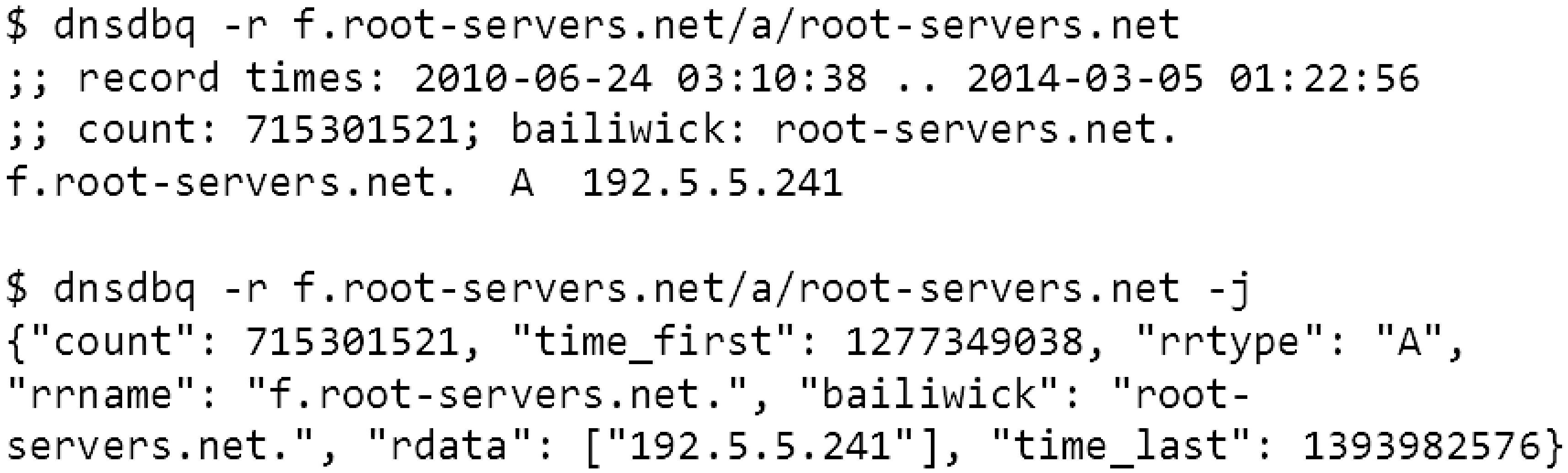
```
$ dnsdbq -i 153.31.119.0/24 | grep -v infragard
vpn.dev2.leo.gov.           A  153.31.119.70
mail.leo.gov.               A  153.31.119.132
www.biometriccoe.gov.       A  153.31.119.135
www.leo.gov.                A  153.31.119.136
cgate.leo.gov.              A  153.31.119.136
www.infraguard.net.         A  153.31.119.138
infraguard.org.             A  153.31.119.138
www.infraguard.org.         A  153.31.119.138
mx.leo.gov.                 A  153.31.119.140
ic.fbi.gov.                 A  153.31.119.142
mail.ic.fbi.gov.            A  153.31.119.142
mail.ncijtf.fbi.gov.        A  153.31.119.142
```

Data Lookup, by IP Address



```
$ dnsdbq -r ic.fbi.gov/mx
ic.fbi.gov.  MX  10 mail.ic.fbi.gov.

$ dnsdbq -r mail.ic.fbi.gov/a
mail.ic.fbi.gov.  A  153.31.119.142

$ dnsdbq -i 153.31.119.142
ic.fbi.gov.           A  153.31.119.142
mail.ic.fbi.gov.      A  153.31.119.142
mail.ncijtf.fbi.gov.  A  153.31.119.142
```

Technical Formatting Notes



```
$ dnsdbq -r f.root-servers.net/a/root-servers.net
;; record times: 2010-06-24 03:10:38 .. 2014-03-05 01:22:56
;; count: 715301521; bailiwick: root-servers.net.
f.root-servers.net.  A  192.5.5.241

$ dnsdbq -r f.root-servers.net/a/root-servers.net -j
{"count": 715301521, "time_first": 1277349038, "rrtype": "A",
"rrname": "f.root-servers.net.", "bailiwick": "root-
servers.net.", "rdata": ["192.5.5.241"], "time_last": 1393982576}
```

DNSDB Deployment Notes

- FSI Passive DNS sensor is open source (PCAP)
  - ‘dnstap’ is coming soon, for server embedding
- The FSI DNSDB API is open (now an IETF I-D)
  - FSI, 360.CN, NIC.AT, &others have servers
- FSI DNSDB is quasi-commercial:
  - Full grant for students (with advisor’s approval)
  - Partial grant for those who operate sensors for us
  - Commercially available for use, resale, embedding

Limited Bibliography

https://www.farsightsecurity.com/
http://www.redbarn.org/dns/ratelimits
http://dnsrpz.info/
https://dnsdb.info/
https://dnstap.info/