Defending your DNS in a post-Kaminsky world

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DNS resilie

June, 2008

Longer TTL's are much safe

The calculations above indicate the relative ease with which DNS data can be spoofed. For example, using the fomula derived earlier on a domain with a 3600 second TTL, an attacker sending 7000 fake response packets/s (a rate of 4.5Mb/s), stands a 10% chance of spoofing a record in the first 24 hours, which rises to 50% after a week.

For a domain with a TTL of 60 seconds, the 10% level is hit after 24 minutes, 50% after less than 3 hours, 90% after around 9 hours.

Note that the attacks mentioned above can be detected by watchful server operators - an unexpected incoming stream of 4.5mbit/s of packets might be noticed.

An important assumption however in these calculations is a known or static destination port of the authentic response.

The IETF

Sunday, July 14, 2008

DNSSEC must happen NOW

CircleID

Wednesday, August 15, 2007

The case against DNSSEC

I was talking to my good friend Verner Entwhistle the other day when he suddenly turned to me and said "I don't think we need DNSSEC". Sharp intake of breath. Transpired after a long and involved discussion his case boiled down to four points:

1. SSL provides known and trusted security, DNSSEC is superfluous 2. DNSSEC is complex and potentially prone to errors 3. DNSSEC makes DoS attacks worse 4. DNSSEC does not solve the last mile problem

Cryp.to New

Sunday, August 17, 2008

DNSCurve will save the day

Bernstein said that DNSSEC offers "a surprisingly low level of security" while causing severe problems for DNS time on breakable patches," Bernstein said. He called for development of DNSSEC alternatives that quickly and securely

Black Hat Bri

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Vendor and NGO's involved

IETF

Nominum
Connecting Networks and People

NeuStar
Trusted to Bring Networks Together

Microsoft

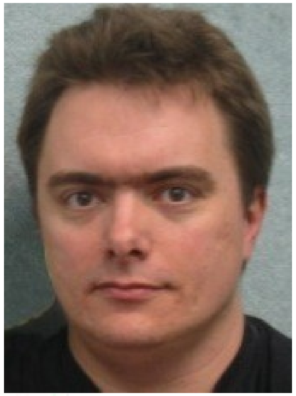
CERT

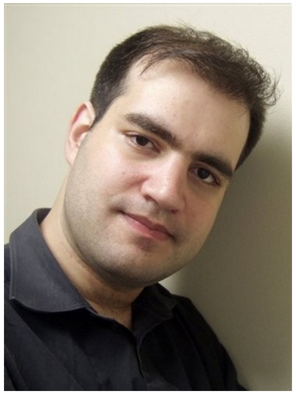
IOActive
COMPREHENSIVE COMPUTER SECURITY SERVICES

NLnet Labs

OpenDNS

ISC Internet Systems Consortium





Two phase deployment

First release a generic fix for the Kaminsky attack that does not leak information to the bad guys (source port randomization)

Then release the bug and patches specifically against the Kaminsky attack

DNS query packet

IP header containing Source IP and Dest IP

UDP or TCP Header containing
Source Port and Dest Port
(if TCP, also random Sequence Number)

DNS Query ID
DNS Query
Option flags

DNS query example

12.110.110.204 ⟶ 193.110.157.136

UDP:12345 ⟶ 53

DNS Query ID: 54321
DNS Question: www.ripe.net?
Option flags: RD

DNS Answer packet

193.110.157.136 → 12.110.110.204

UDP:53 → 12345

QUESTION SECTION
Query ID: 54321
Question: www.ripe.net?

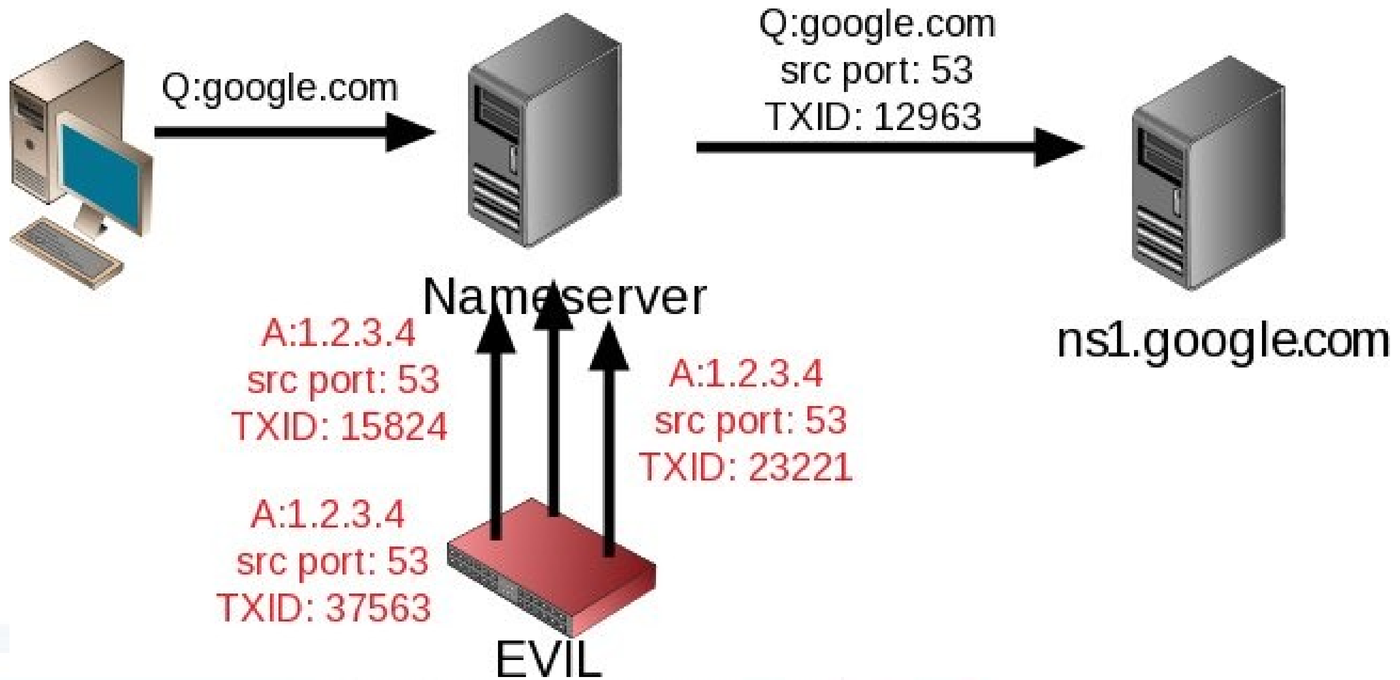
ANSWER SECTION
www.ripe.net = 193.0.0.195 (ttl=172800)

AUTHORITY SECTION
ripe.net NS ns-pri.ripe.net. (ttl=172800)
ripe.net NS ns-ext.isc.org. (ttl=172800)

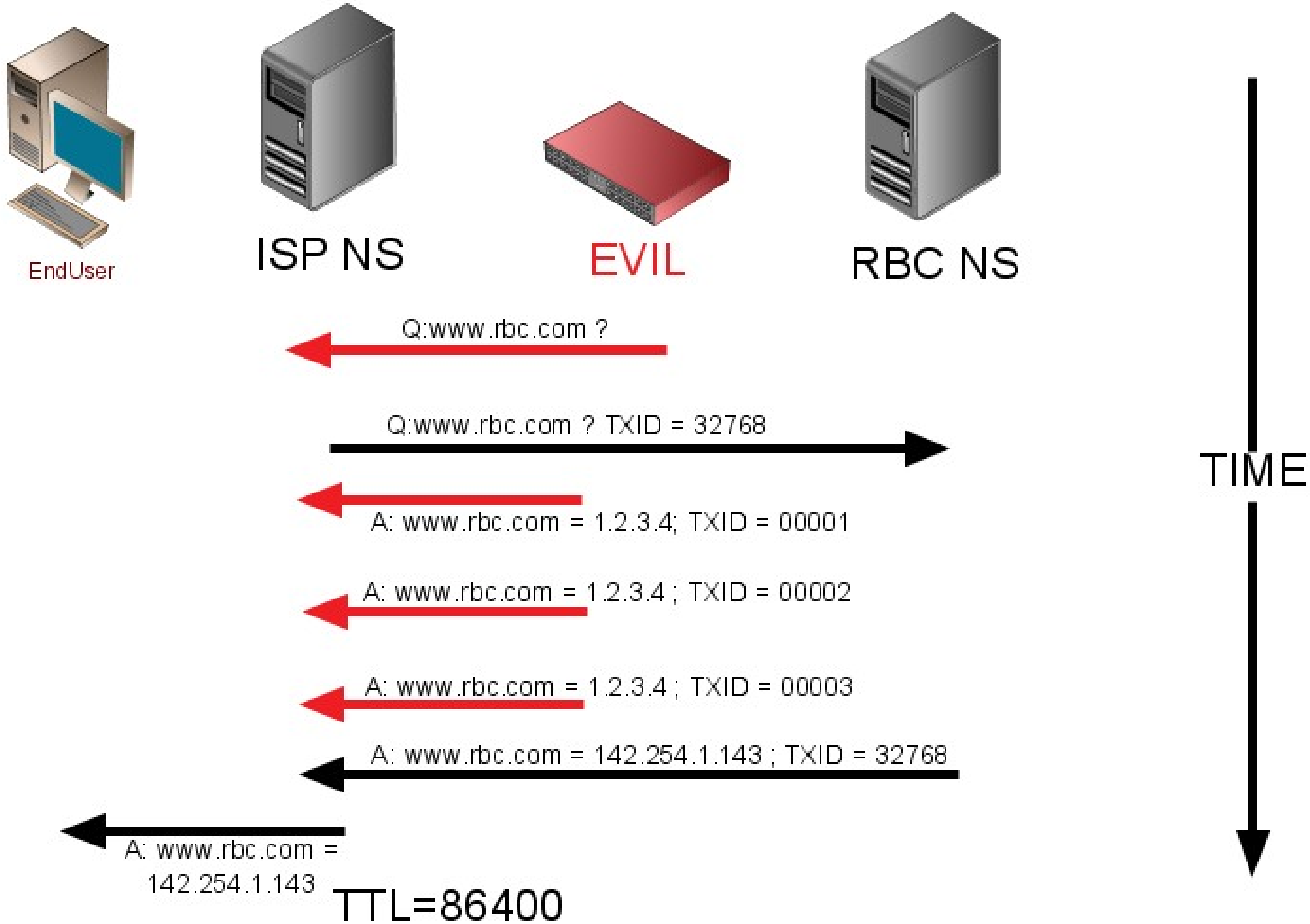
ADDITIONAL SECTION
ns-pri.ripe.net A 193.0.0.195 (ttl=…)
ns-pri.ripe.net AAAA 2001:610:240:0:53:3

TXID is not enough anymore

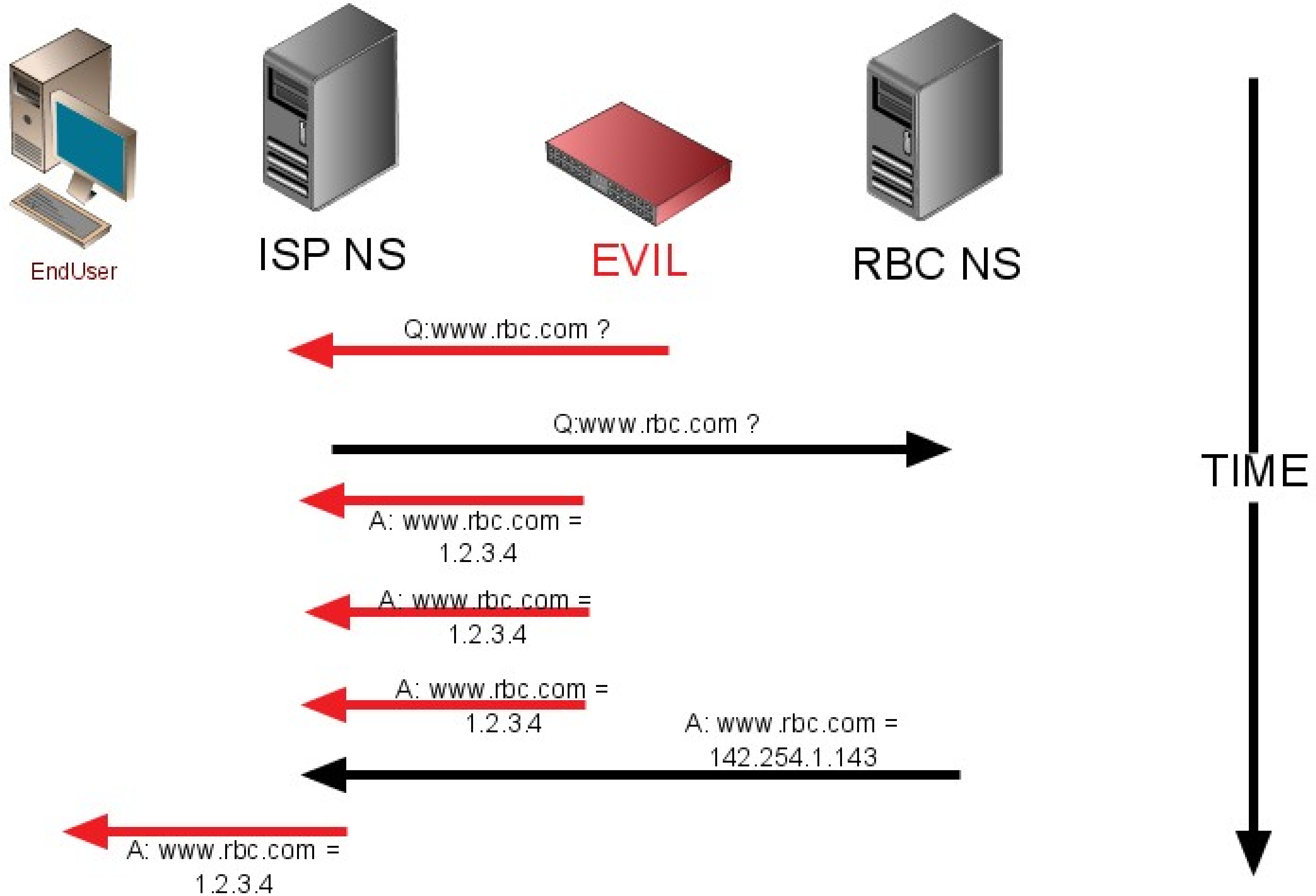
Bellowin's (theoretical) attack (1995)



Losing the race

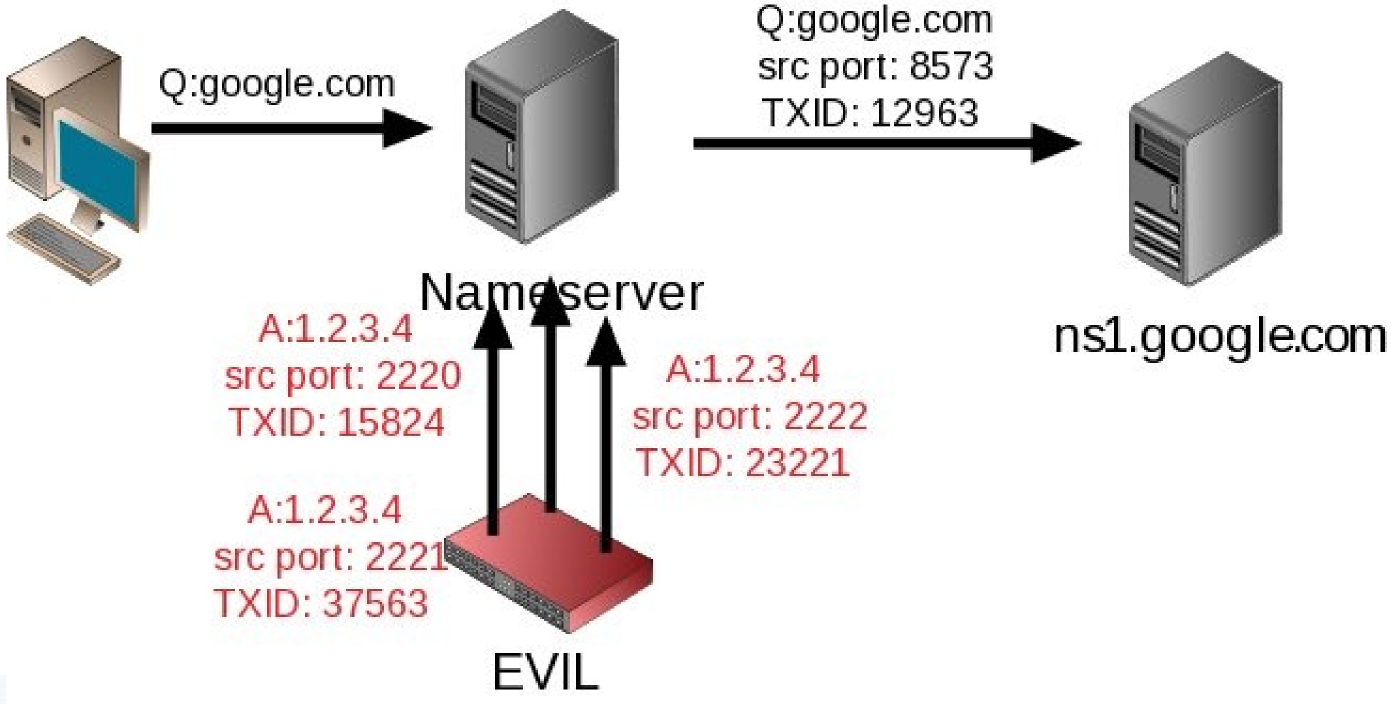


Winning the race

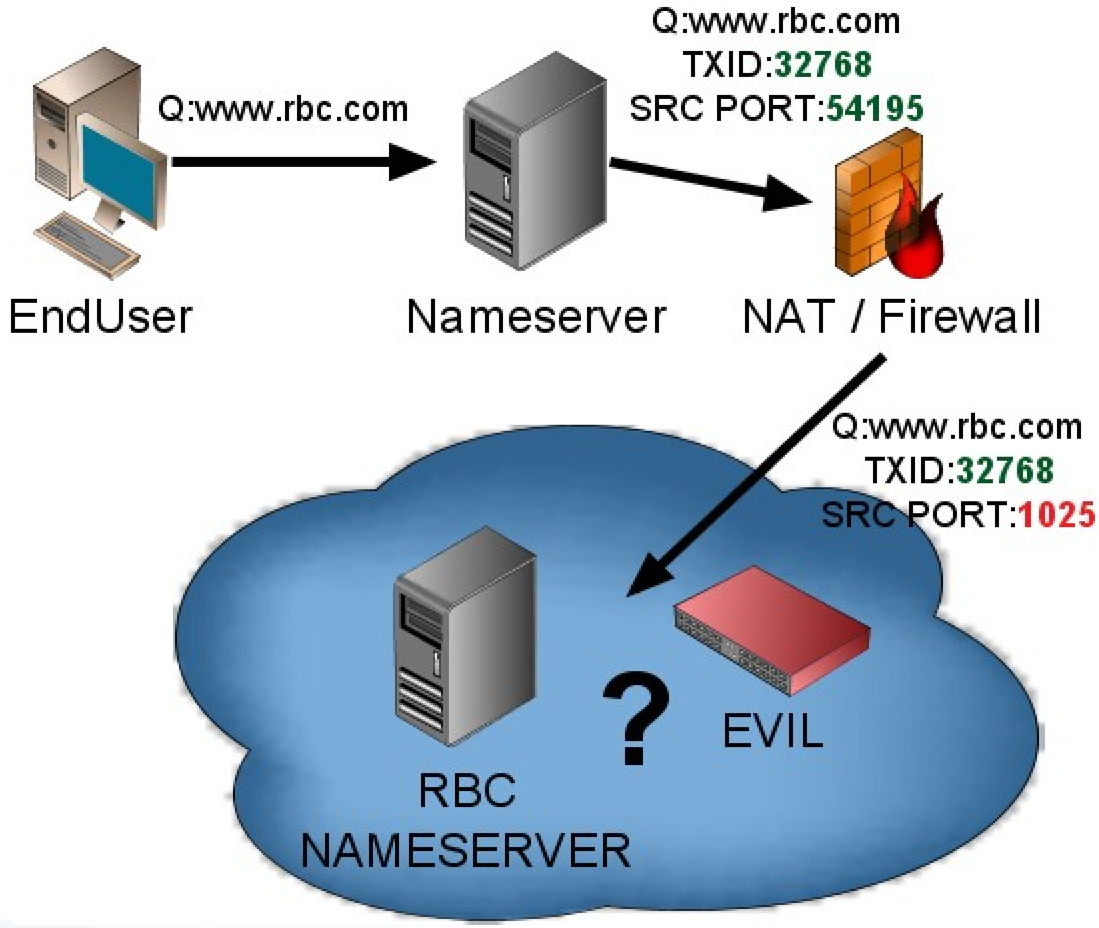


Random source ports

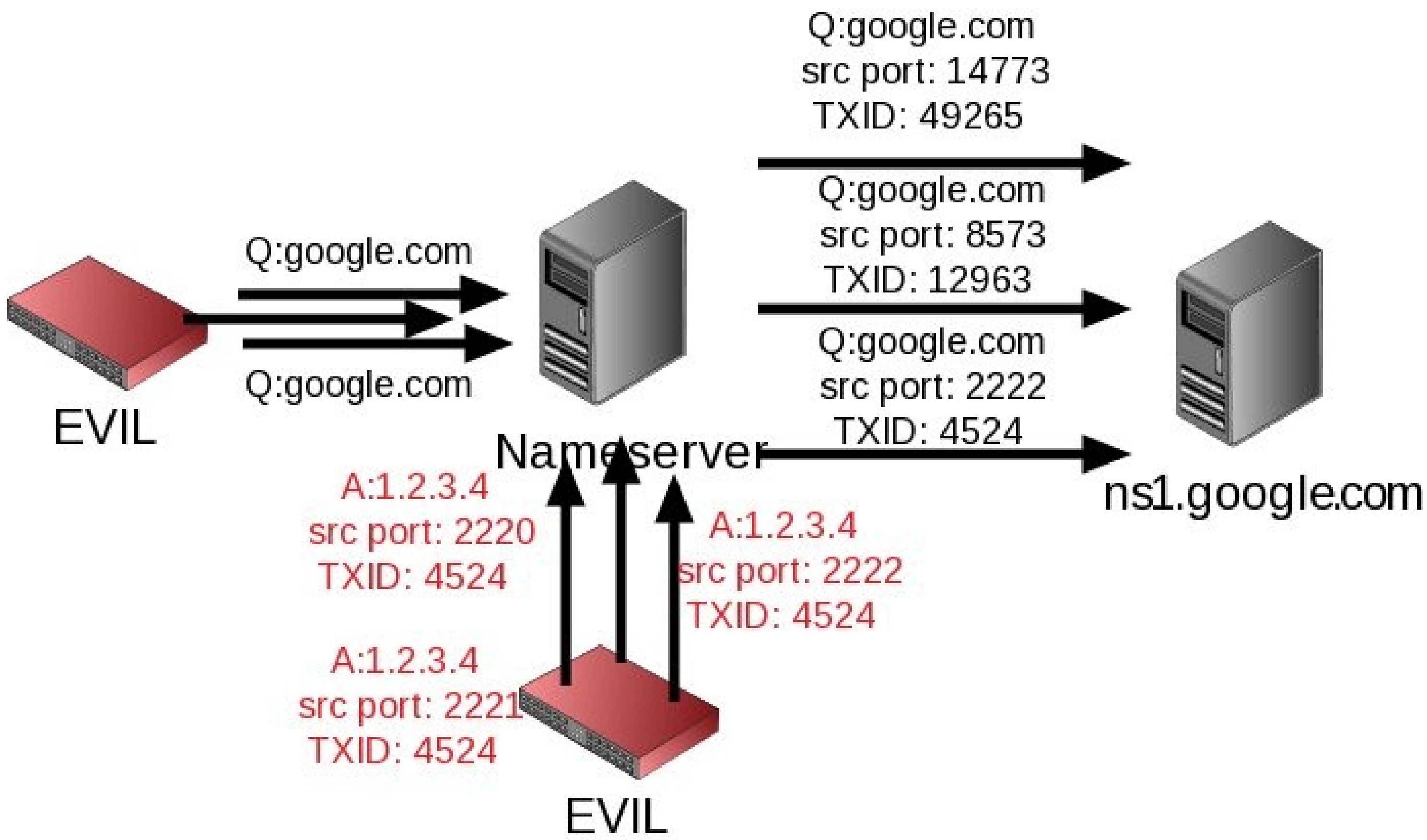
Bernstein:Use random src ports as entropy



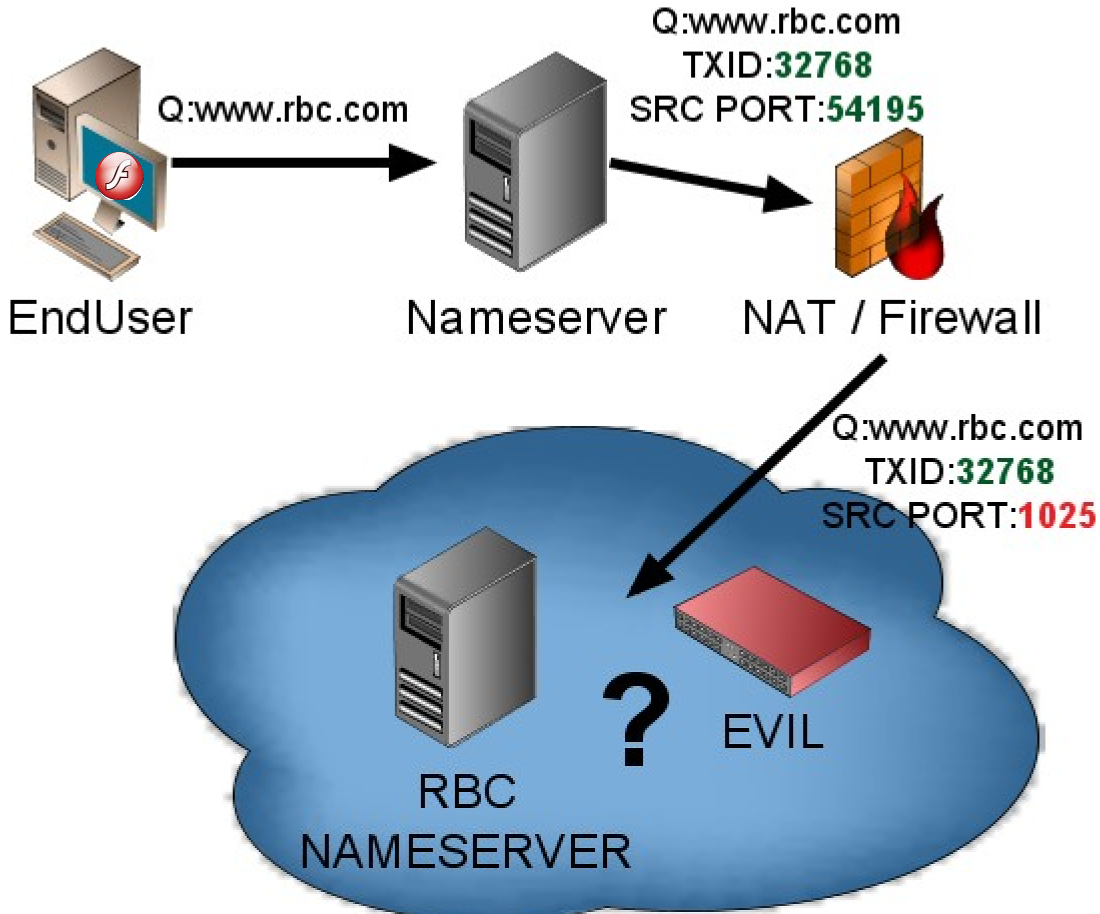
DJB's hack is still just a hack



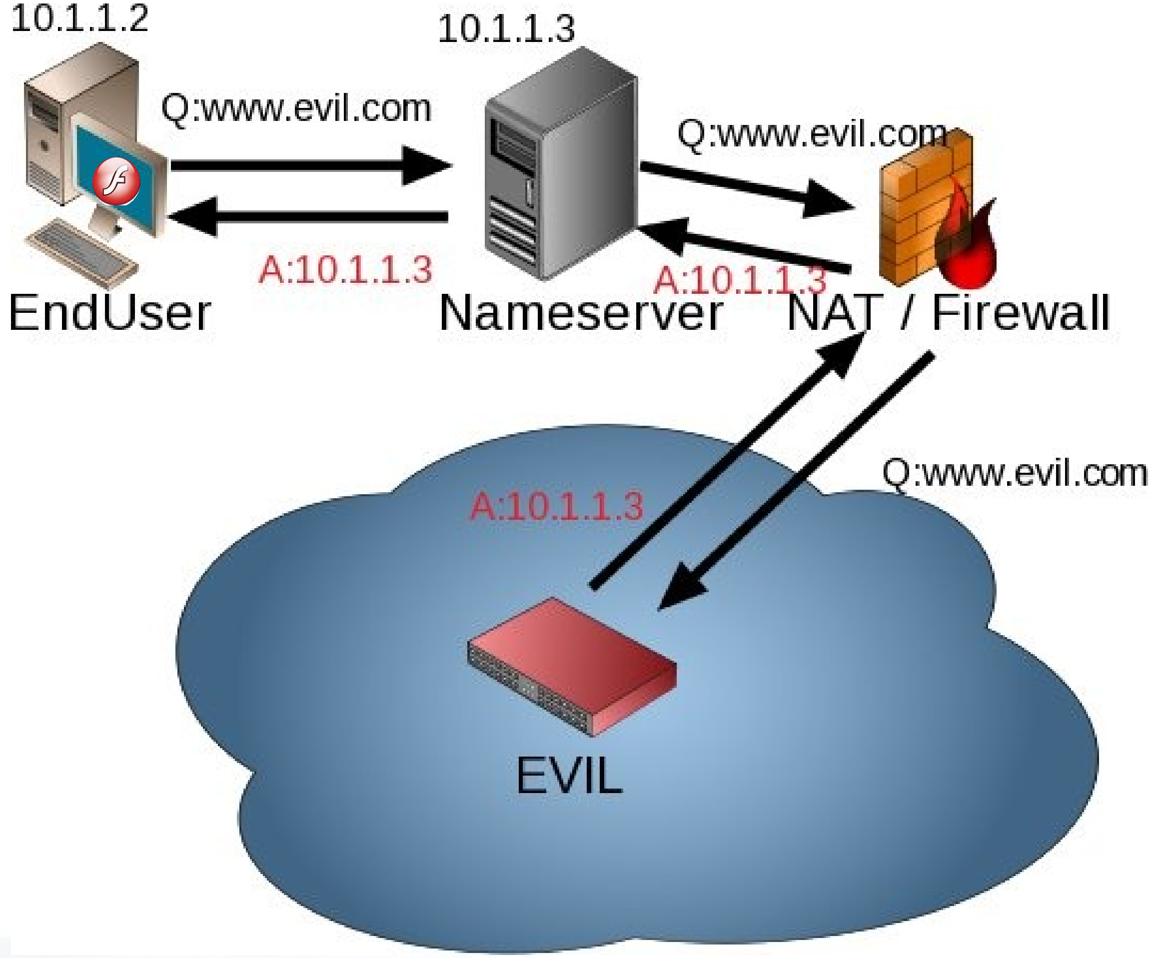
Birthday Attack on src ports



NAT and DNS rebinding



NAT and DNS rebinding (2)



Kasphureff's attack (1997) caused Bailywick restrictions

QUESTION SECTION
Query ID: 54321
Question: www.ripe.net?

ANSWER SECTION
www.ripe.net = 193.0.0.195 (ttl=172800)

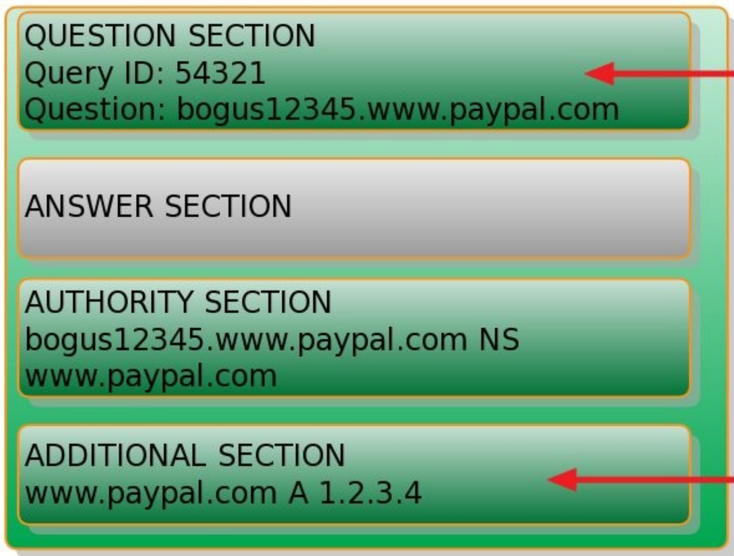
AUTHORITY SECTION
ripe.net NS ns-pri.ripe.net.
ripe.net NS ns-ext.isc.org.

ADDITIONAL SECTION
www.paypal.com A 1.2.3.4 (ttl=FOREVER)
google.com NS ns.myevildomain.com.

What protected our DNS?

- The attacker cannot see your packet
  - You always lose at StarBucks and TOR
- Transaction ID (TXID)
- Time To Live (TTL)
- Bailywick

The Kaminsky Attack



If you lose the race, try bogus12346

Overrides cache

Without source port randomization, this only takes about 65535 packets

DNS related issues: Double Fast Flux

- Botnets use domains with NS and A records with low (eg 3 minute) TTL's
- Change NS records via Registrar very quickly too (hours)

- This makes them next to impossible to shutdown.

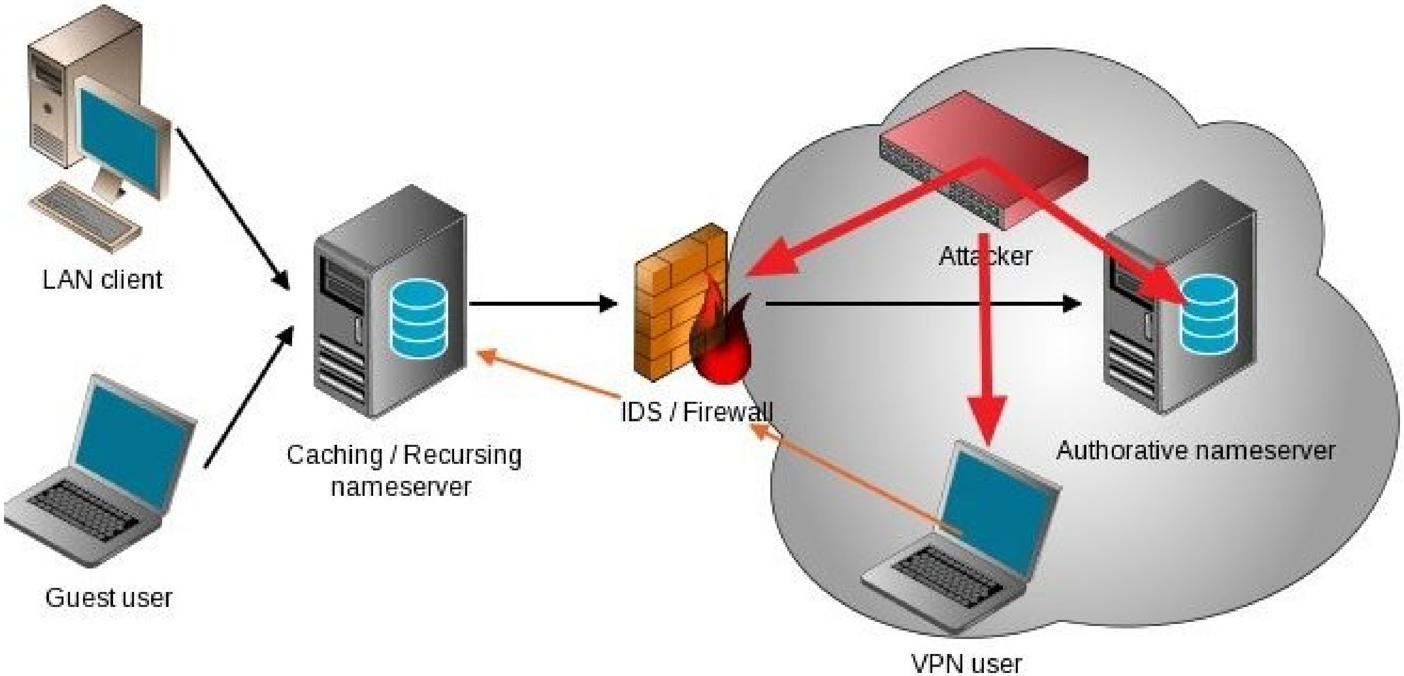
(and soon OpenDNS commercial double fast flux)

DNS related issues: The Wifi hotspot

- Captive portals using DNS with mini DNS "server"
- This is so they can serve fake DNS
- This can cause client to cache wrong DNS
- Bad implementations break on EDNS and DNSSEC (hardcoded bits checking)

- Use transparent IP proxy instead

Where to fix the DNS ?



DNS is critical infrastructure

- Backwards compatible (opt-in)
- Non-invasive or intrusive (drop-in)
- Non-disruptive (no CPU/Bandwidth hog)
- No Protocol changes(we have DNSSEC)
- Preferably no TYPE overloading
- No magic such as untested cryptography
- Patent / Royalty free

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Thou Shalt Implement:

BCP 38

(Egress Filtering)

Thou Shalt not:

combine a recursive and authoritative server

Authorative nameservers

- Upgrade server to allow DNSSEC
- Diversify your infrastructure

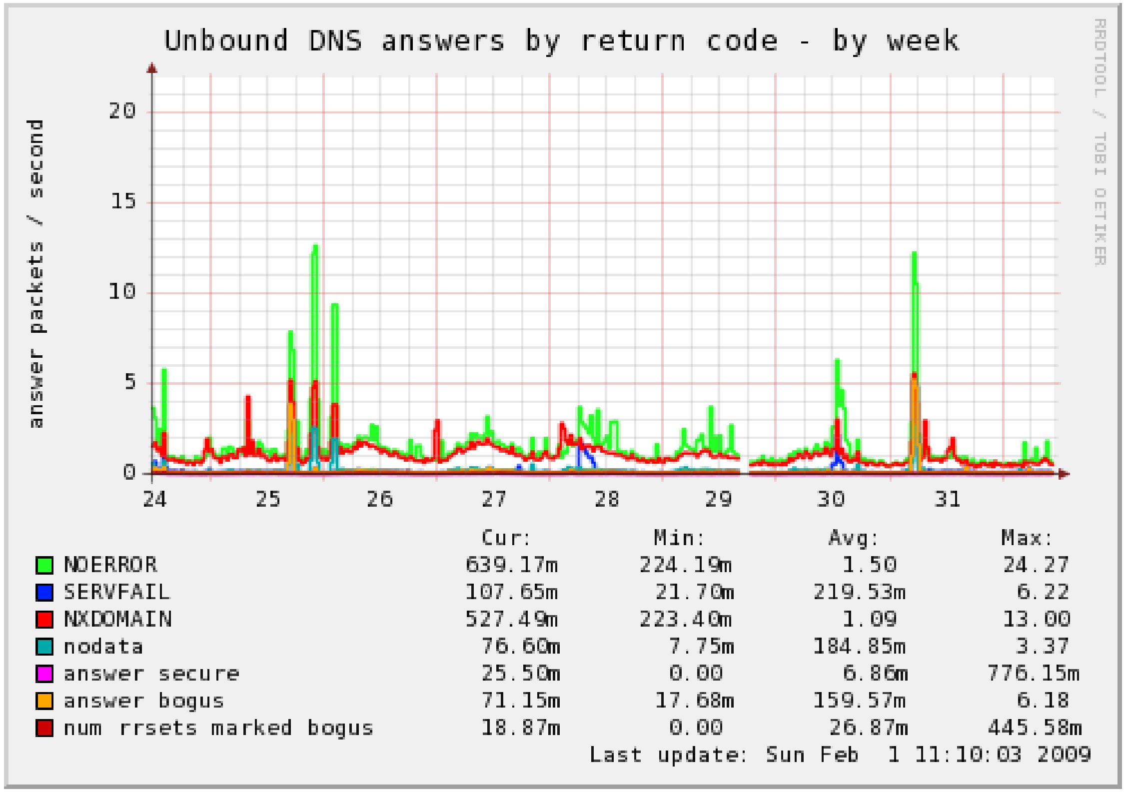
```
; <<>> DiG 9.6.0a1 <<>> -t ns xelerance.com
;; global options:  printcmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 57177
;; flags: qr rd ra; QUERY: 1, ANSWER: 3, AUTHORITY: 0, ADDITIONAL: 2

;; QUESTION SECTION:
;xelerance.com.                 IN      NS

;; ANSWER SECTION:
xelerance.com.          844     IN      NS      ns2.xelerance.org.
xelerance.com.          844     IN      NS      ns0.xelerance.nl.
xelerance.com.          844     IN      NS      ns1.xelerance.net.

;; ADDITIONAL SECTION:
ns0.xelerance.nl.       972     IN      A       193.110.157.135
ns1.xelerance.net.      98036   IN      A       209.237.247.134

;; Query time: 118 msec
;; SERVER: 193.110.157.2#53(193.110.157.2)
;; WHEN: Sat Jan 31 12:05:29 2009
;; MSG SIZE  rcvd: 142
```

Network IDS / Firewall

- It's patch work (pun intended)
- Does not address the problems
- Cannot make a decision when an attack is detected. What to do? Blocking is bad (denial of service to yourself)

- Monitor, log and warn. Do not interfere
- Be very careful with DNS load balancers

Monitor Unix based DNS



Monitoring using Cisco

www.cisco.com/web/about/security/intelligence/dns-bcp.htm

```
policy-map type inspect dns preset_dns_map
  parameters
    !--- TXID matching – allow only 1 response
    dns-guard
    id-randomization
    id-mismatch count 10 duration 2 action log
    message-length maximum 512
    match header-flag RD
      drop
```

Monitoring using Cisco

firewall# show service-policy inspect dns

Global policy:

Service-policy: global_policy

Class-map: inspection_default

Inspect: dns preset_dns_map, packet 37841, drop 0, reset-drop 0

~~message-length maximum 512, drop 0~~

dns-guard, count 21691

protocol-enforcement, drop 0

nat-rewrite, count 0

id-randomization, count 21856

id-mismatch count 10 duration 2, log 2

Application fixes

- So many different applications to fix
- DNS API for applications is poor
- Easy to fool: DNS Rebinding or Fast Flux
- But let's not build DNS recursive nameservers in every application

(however a good recursive dns server on each host is a good solution)

The inevitable:
Fix recursive nameservers

Port randomization

Sanitize TTL's

Use more IP addresses per DNS server

Harden against bogus size packets

Harden glue

Additional queries for infrastructure data

0x20

Birthday Attack protection

- Do not allow multiple queries for the same question to be outstanding (AKA query chaining)

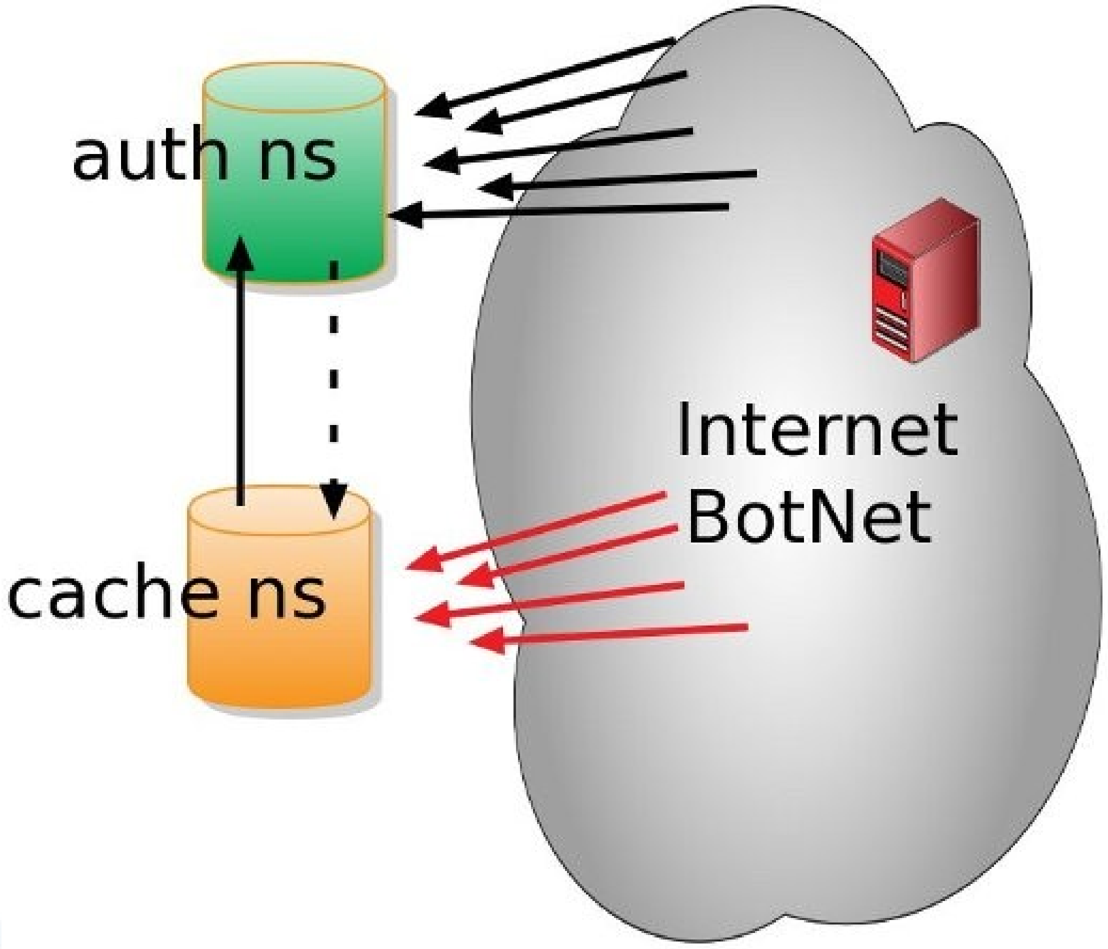
  Unbound, Bind and PowerDNS implement this properly
- dnscache from DJB was apparently vulnerable to this until a few days ago!

Rebinding protection

Allow to specify IP addresses that may never appear in “external” domain names

This way you can ensure 10.1.1.0/24 would never come in through DNS rebinding.
(supported in Unbound and PowerDNS)

Attacks can be detected



Attack response #1

- At a spoof detection threshold, ignore all answers for that query
- Prevents accepting the right forged answer
- Also prevents accepting the **real** answer spoofmax=?
- Small value : easy DOS
- Large value: might be too late (PowerDNS has spoofmax=20)

Attack response #2

- At a spoof detection threshold throw away the **entire** cache and start from scratch
- Prevents using an accepted forged answer
- Small value : easy DOS on the cache
- Large value: might be too late (Unbound has spoofmax=10M)

Chain your caches
(esp. the ones behind NAT)

Add more NS records?

If you already have at least two or three, this does not buy you much

Only makes an attack marginally harder

Excessive NS records cause other problems (and adds more potentially outdated / vulnerable nameservers)

Pick nameserver more random

Old days: prefer nameserver with shortest TTL

New ways: Add some fuzz

Hardening infrastructure queries

Before accepting NS records or A records of nameservers, ask **at least** two different nameservers.

Before accepting glue records or additional data, independently verify these with new queries.

(extra work is only needed once, then we use caching – minimum impact)

The 0x20 defense (Paul Vixie)

DNS Question: bogus12345.www.paypal.com?
Option flags: RD

The 0x20 defense (Paul Vixie)

DNS Question: bogus12345.www.paypal.com?
Option flags: RD

DNS Query ID: **54321**
DNS Question: bOGus12345.WwW.pAYpaL.Com

The 0x20 defense (Paul Vixie)

DNS Query ID: **54321**
DNS Question: bOGus12345.WwW.pAYpaL.Com

QUESTION SECTION
Query ID: **54321**
Question: BoGUs12345.wWW.pAYPal.cOM

ANSWER SECTION

AUTHORITY SECTION
bogus12345.www.paypal.com NS www.paypal.com

ADDITIONAL SECTION
www.paypal.com A 1.2.3.4

The 0x20 defense (Paul Vixie)

- You don't need “Td-CaNAdaTRuSt.cOm” when you can get “.CoM”
- Fails completely for the root (“.”)

Double Fast Flux protection

Draft-bambenek-doubleflux suggests:

Replacing the TTL's of NS and A records of NS records with TTL=72 hours.

Llimit Registrar changes to once per 72h

Recursors and clients should drop NS or A of NS with TTL < 12

The inevitable:
Fix recursive nameservers

- RFC 5452 “Measures for Making DNS More Resilient against Forged Answers”
- draft-wijngaards-dnsext-resolver-side-mitigation
- draft-vixie-dnsext-0x20

The real solution

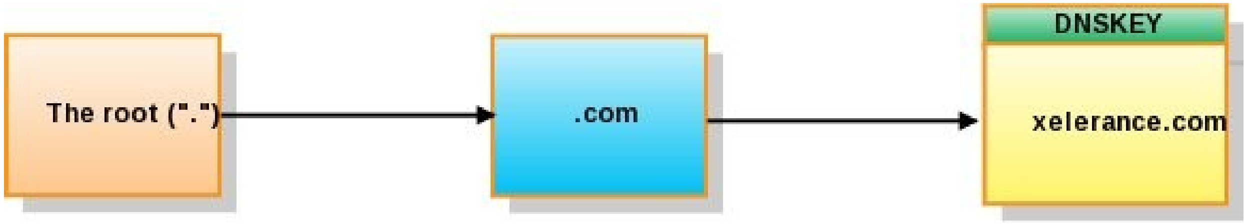
DNSSEC

What is DNSSEC?

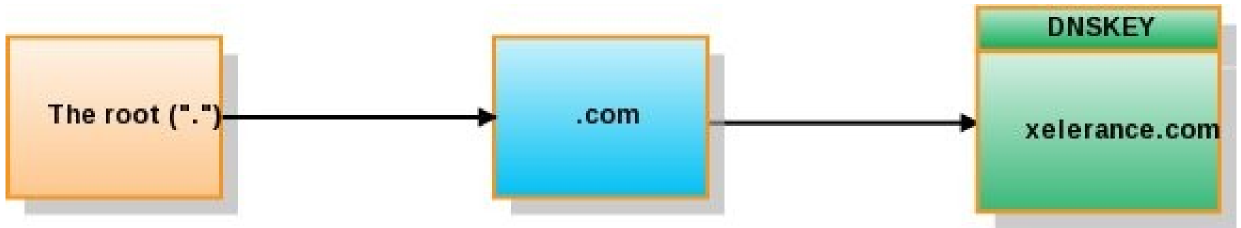
- Authenticate (non)existence of data within a zone
- Create a path of trust between zones
- Sign and preload the root (“.”) key

Traditional DNS

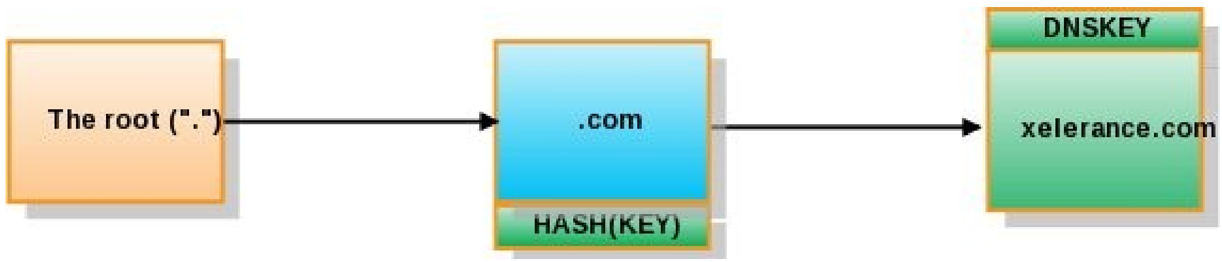
Add a public key to zone



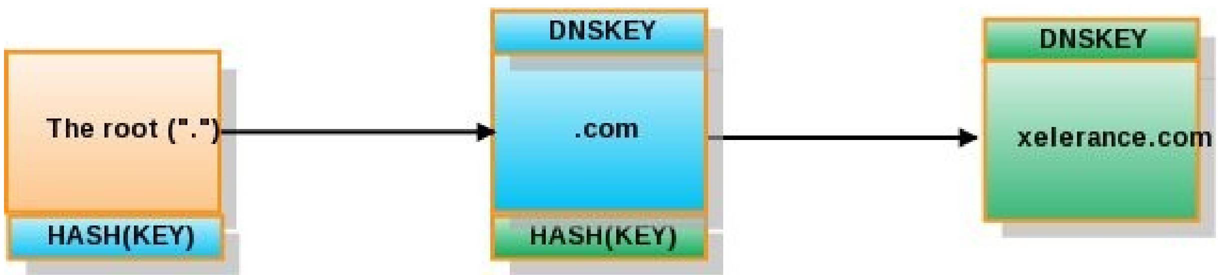
Sign zone with private key



Give hash(pubkey) to parent



Rinse and Repeat



New DNS Record types

DNSKEY	Public key
RRSIG	Signature RRset
NSEC	“Clever” Record denial of existence
NSEC3	“Super Clever” Record stealthy denial of existence
DS	Delegation Signer r.

DNSSEC answers can be:

SECURE	Validated with key
INSECURE	Validated but no key
BOGUS	validation failed
UNKNOWN	ServFail etc

DNSSEC bits

The DO bit (query)	DNSSEC (is) OK
The AD bit (answer)	Authenticated Data
The CD bit (query)	Checking Disabled

New DNSSEC errors

- Uhm, none. For maximum compatibility. If any error happens, return the old ServFail.

- A validator can then redo the query with the CD bit if it wants to see why it failed

Let's see some DNSSEC...

Unlike Adam Laurie and Johnny Long,

I have no cool Hollywood clip I can show

```
bofh.xelerance.com.      3600    IN A     193.110.157.17
                         3600    RRSIG    A 5 3 3600 20090314165933 (
                                          20090212165933 16352 xelerance.com.
                                          ohgclaigYWLdUYt13xQRjCNtdleLtaQC1sXp[...])
                         3600    NSEC     bugs.xelerance.com. A RRSIG NSEC
                         3600    RRSIG    NSEC 5 3 3600 20090314165933 (
                                          20090212165933 16352 xelerance.com.
                                          H5Cr4Z8ovjW8lfwCCHBvOi2fiD3zX25NDAth[...])
bugs.xelerance.com.      3600    IN A     193.110.157.129
                         3600    RRSIG    A 5 3 3600 20090314165933 (
                                          20090212165933 16352 xelerance.com.
                                          dmWVWxzkYXQvzxWwCNwH3jdGTWqwQE5PHFPR[...])
                         3600    NSEC     build.xelerance.com. A RRSIG NSEC
                         3600    RRSIG    NSEC 5 3 3600 20090314165933 (
                                          20090212165933 16352 xelerance.com.
                                          NLTif8GabVKXmtnWKUtIAGkHD5dPr+yGhAgM[...])
build.xelerance.com.     3600    IN A     193.110.157.194
                         3600    RRSIG    A 5 3 3600 20090314165933 (
                                          20090212165933 16352 xelerance.com.
                                          nEQpOj6e2aAT+B76jlH0dMqIKy6+PwI1bB4s[...])
                         3600    NSEC     calendar.xelerance.com. A RRSIG NSEC
                         3600    RRSIG    NSEC 5 3 3600 20090314165933 (
                                          20090212165933 16352 xelerance.com.
                                          Lfk6EoDquybGeDqi7z75O04x3mtFNPpgOwTr[...])
calendar.xelerance.com. 3600    IN A     193.110.157.130
```

```
; <<>> DiG 9.6.0a1 <<>> +multiline +dnssec -t ds nic.cz @193.110.157.136
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 44991
;; flags: qr rd ra ad; QUERY: 1, ANSWER: 3, AUTHORITY: 7, ADDITIONAL: 1
;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags: do; udp: 4096
;; QUESTION SECTION:
;nic.cz.                        IN DS
;; ANSWER SECTION:
nic.cz.                 445 IN DS 59916 5 1 (
                                144130216E45C4EC2BB8595E817916E8B060D87B )
nic.cz.                 445 IN DS 27979 5 1 (
                                FF11E740A0254EC63C738A47E52ABF3AD91D8C43 )
nic.cz.                 445 IN RRSIG DS 5 2 1800 20090314003628 (
                                20090212003628 4092 cz.
                                c4p82mdTbbydVihi9HP8f8k1qNOnWYfJemdAF7Zk78L/[...])
;; AUTHORITY SECTION:
cz.                     16645 IN NS d.ns.nic.cz.
cz.                     16645 IN NS f.ns.nic.cz.
cz.                     16645 IN NS a.ns.nic.cz.
cz.                     16645 IN NS c.ns.nic.cz.
cz.                     16645 IN NS e.ns.nic.cz.
cz.                     16645 IN NS b.ns.nic.cz.
cz.                     16645 IN RRSIG NS 5 1 18000 20090313023545 (
                                20090211023545 4092 cz.
                                xONjUdAHTieDwrVK3En/CmV0oM6JJUTiF5QczRuscHrM[...])
```

NSEC: Denial of existence

```
                        3600    NSEC    _sip._tcp.xelerance.com. A NS SOA MX TXT NAPT
R SSHFP RRSIG NSEC DNSKEY
                        3600    RRSIG   NSEC 5 2 3600 20090314165933 (
                        3600    NSEC    _sip._udp.xelerance.com. SRV RRSIG NSEC
                        3600    RRSIG   NSEC 5 4 3600 20090314165933 (
                        3600    NSEC    admin.xelerance.com. SRV RRSIG NSEC
                        3600    RRSIG   NSEC 5 4 3600 20090314165933 (
                        3600    NSEC    aivd.xelerance.com. A SSHFP RRSIG NSEC
                        3600    RRSIG   NSEC 5 3 3600 20090314165933 (
                        3600    NSEC    conference.aivd.xelerance.com. A RRSIG NSEC
                        3600    RRSIG   NSEC 5 3 3600 20090314165933 (
                        3600    NSEC    monitor.ams.xelerance.com. A RRSIG NSEC
                        3600    RRSIG   NSEC 5 4 3600 20090314165933 (
                        3600    NSEC    bofh.xelerance.com. CNAME RRSIG NSEC
                        3600    RRSIG   NSEC 5 4 3600 20090314165933 (
                        3600    NSEC    bugs.xelerance.com. A RRSIG NSEC
                        3600    RRSIG   NSEC 5 3 3600 20090314165933 (
                        3600    NSEC    build.xelerance.com. A RRSIG NSEC
                        3600    RRSIG   NSEC 5 3 3600 20090314165933 (
                        3600    NSEC    calendar.xelerance.com. A RRSIG NSEC
                        3600    RRSIG   NSEC 5 3 3600 20090314165933 (
                        3600    NSEC    calender.xelerance.com. A RRSIG NSEC
                        3600    RRSIG   NSEC 5 3 3600 20090314165933 (
                        3600    NSEC    cdc.xelerance.com. A RRSIG NSEC
                        3600    RRSIG   NSEC 5 3 3600 20090314165933 (
```

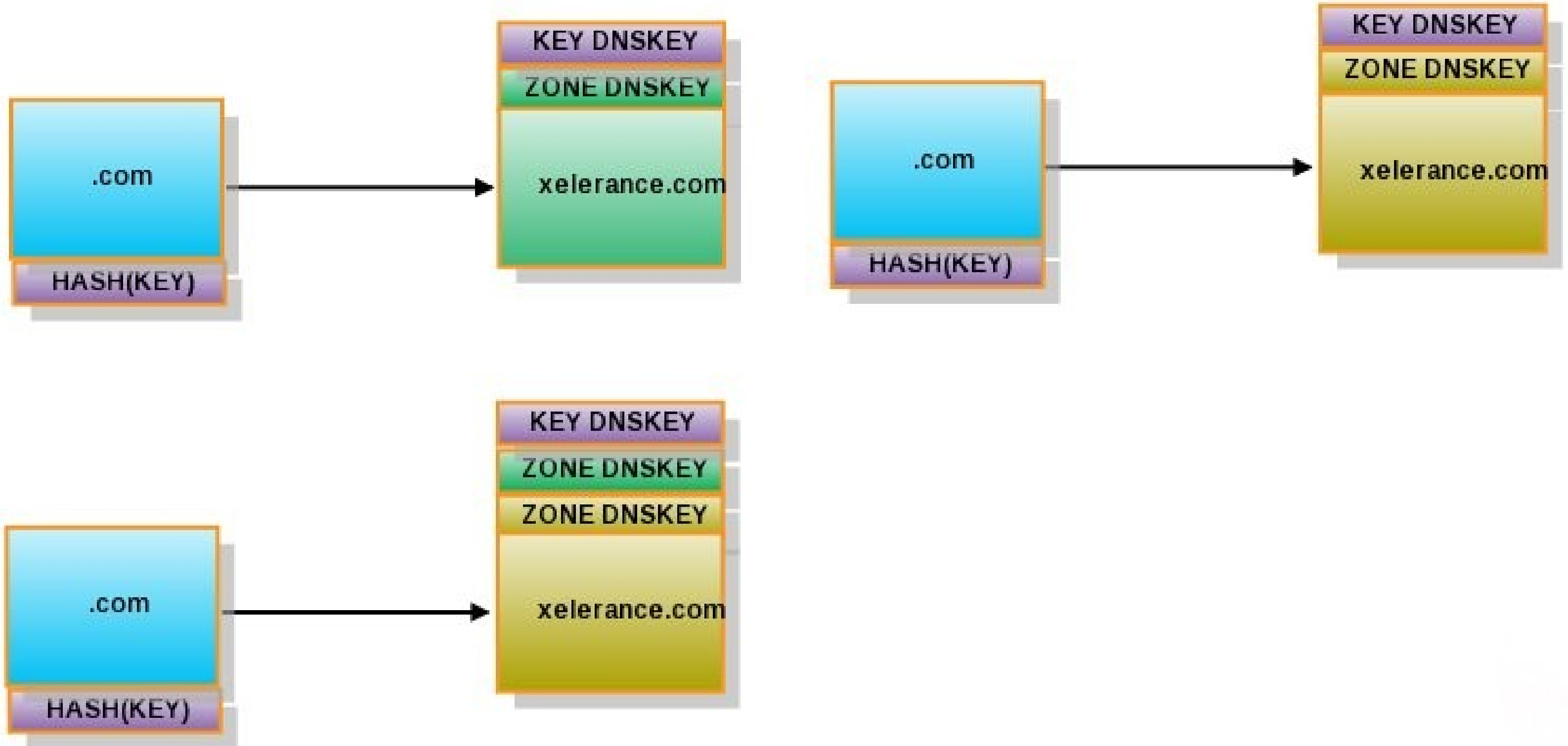
NSEC3: denial of existence with a hack

- Do not use names, but hashes
- For added work, hash X times
- Now sort the hashes

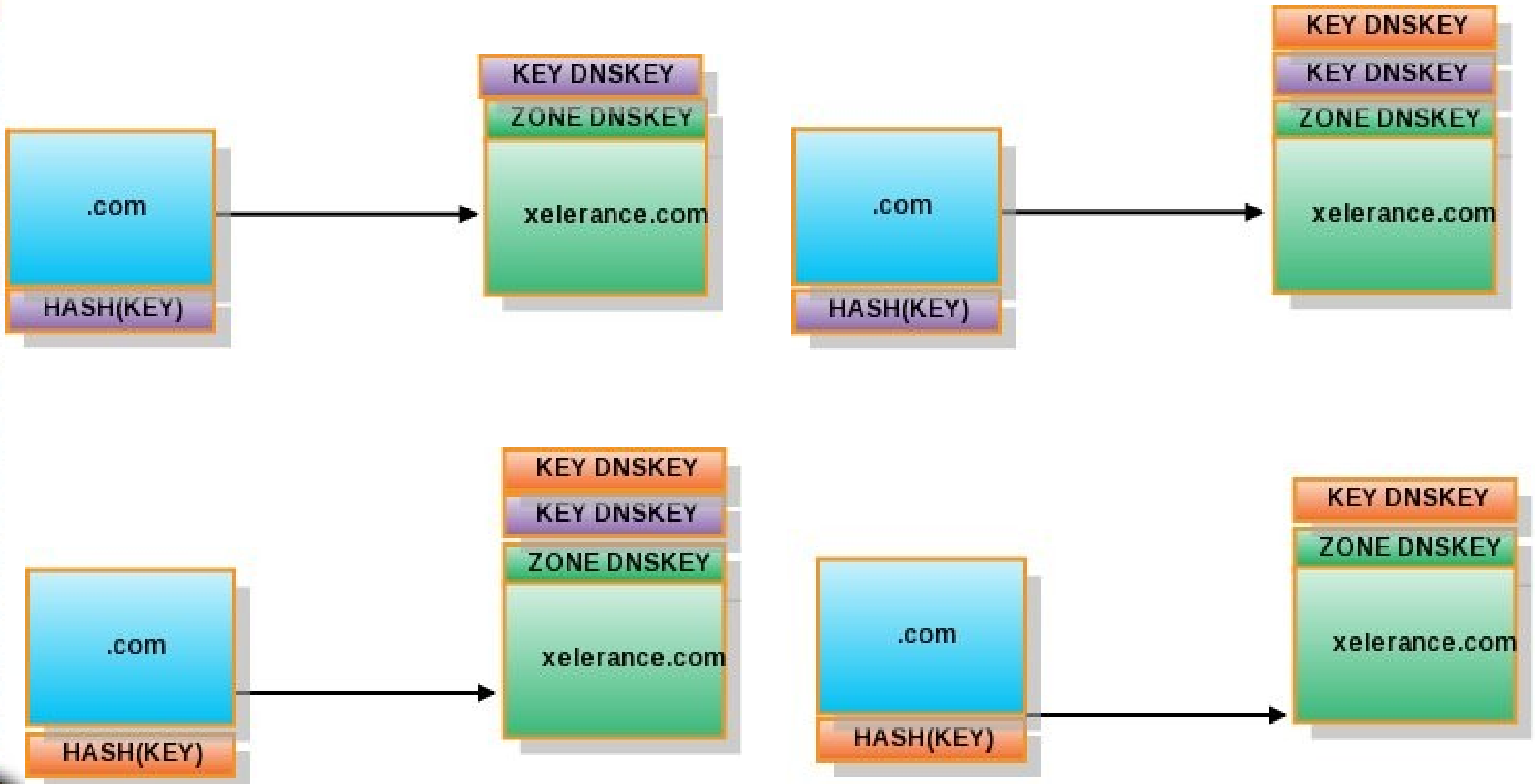
The validator that gets an NSEC3 record back, hashes the QUERY name (x times) too and compares

```
; <<>> DiG 9.6.0a1 <<>> +multiline +dnssec -t ns hhhh.gov @193.110.157.136
;; flags: qr rd ra ad; QUERY: 1, ANSWER: 0, AUTHORITY: 8, ADDITIONAL: 1

;; AUTHORITY SECTION:
gov.                    86381 IN SOA A.GOV.ZONEEDIT.COM. govcontact.ZONEEDIT.COM. (
                                1234994462 ; serial
                                3600       ; refresh (1 hour)
                                900        ; retry (15 minutes)
                                1814400    ; expire (3 weeks)
                                86400      ; minimum (1 day)
                                )
gov.                    86381 IN RRSIG SOA 7 1 259200 20090223210103 (
                                20090218210103 31802 gov.
                                kF4kRKyTIok/tuMdrBB+fsmm5+9HYunPGuO5292z3+B1[...])
VVSOMCNUB7A79EALVJEH4VN12192C715.gov. 86381 IN NSEC3 1 0 10 ABAB 0002H1U5Q5HGQCITMSB0
QRETCK0N6FLT NS SOA RRSIG DNSKEY NSEC3PARAM
VVSOMCNUB7A79EALVJEH4VN12192C715.gov. 86381 IN RRSIG NSEC3 7 2 86400 20090223210103 (
                                20090218210103 31802 gov.
                                SazLRlNSEo39CnOfzWDs/zI8g4qFw5Mm61vZ9neuptfG[...])
                                gOYCZA6nrzJDKAkwNlTXLLnfA6kOvyJdfA== )
AJBACCGUPENCE2AA1RNHHLUFHA37G18F.gov. 86381 IN NSEC3 1 0 10 ABAB AJFCCN9I57OTBLMTTFS3
H3IREPVOI9TJ NS
AJBACCGUPENCE2AA1RNHHLUFHA37G18F.gov. 86381 IN RRSIG NSEC3 7 2 86400 20090223210103 (
                                20090218210103 31802 gov.
                                OKfqMdW4sV9tvFVH/FY45EPYa53C1qD2px37m2J5a9h8
```

DNSSEC: Use Zone and Key Signing keys



DNSSEC: Key Signing Key Rollover



DNSSEC: Key update Triggers or Timers?

- For DNSSEC: Key update from child to parent
- For most domains: Any updates via Registrant to Registrar to Registry
- For some domains: Registrant – Registry communication
- Most common solution will be EPP via Registrar. Some by Registry polling

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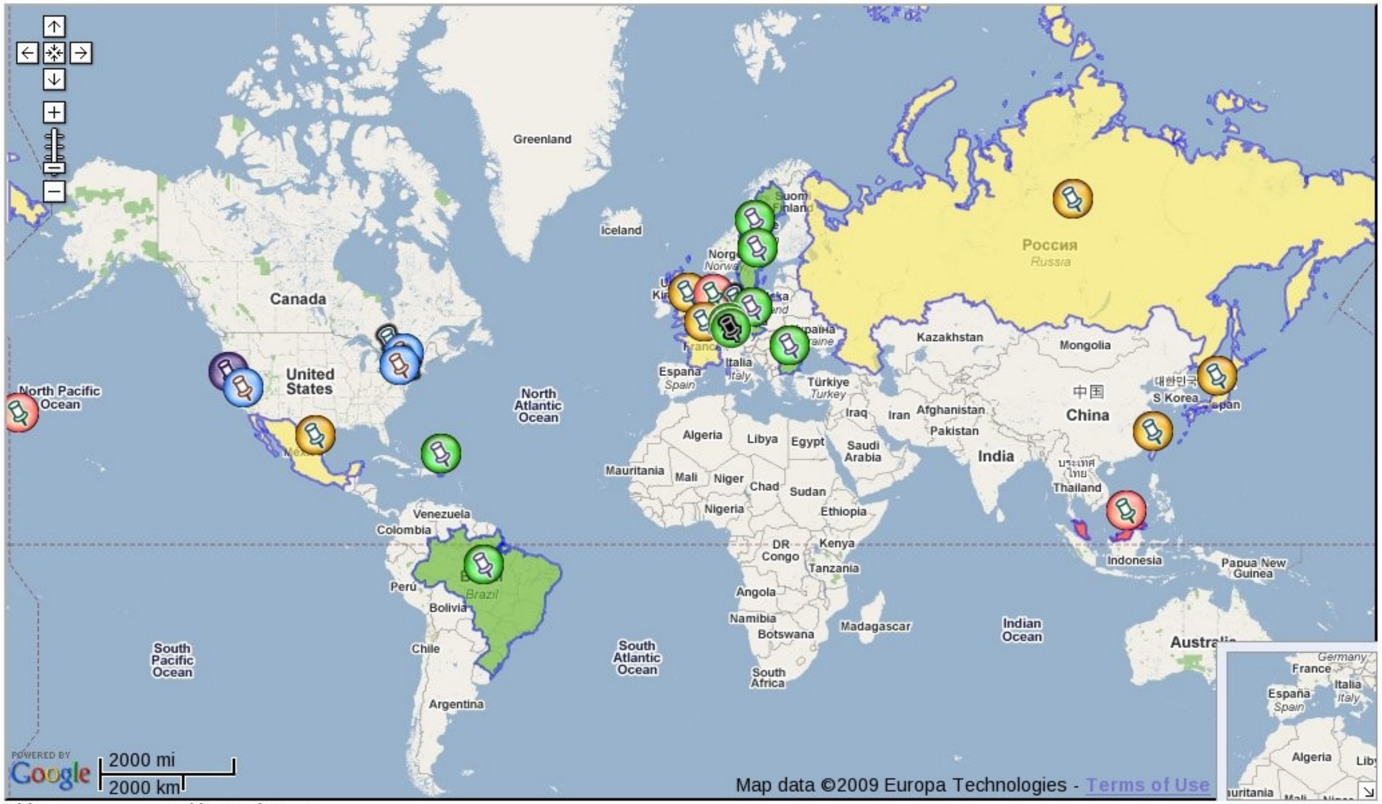
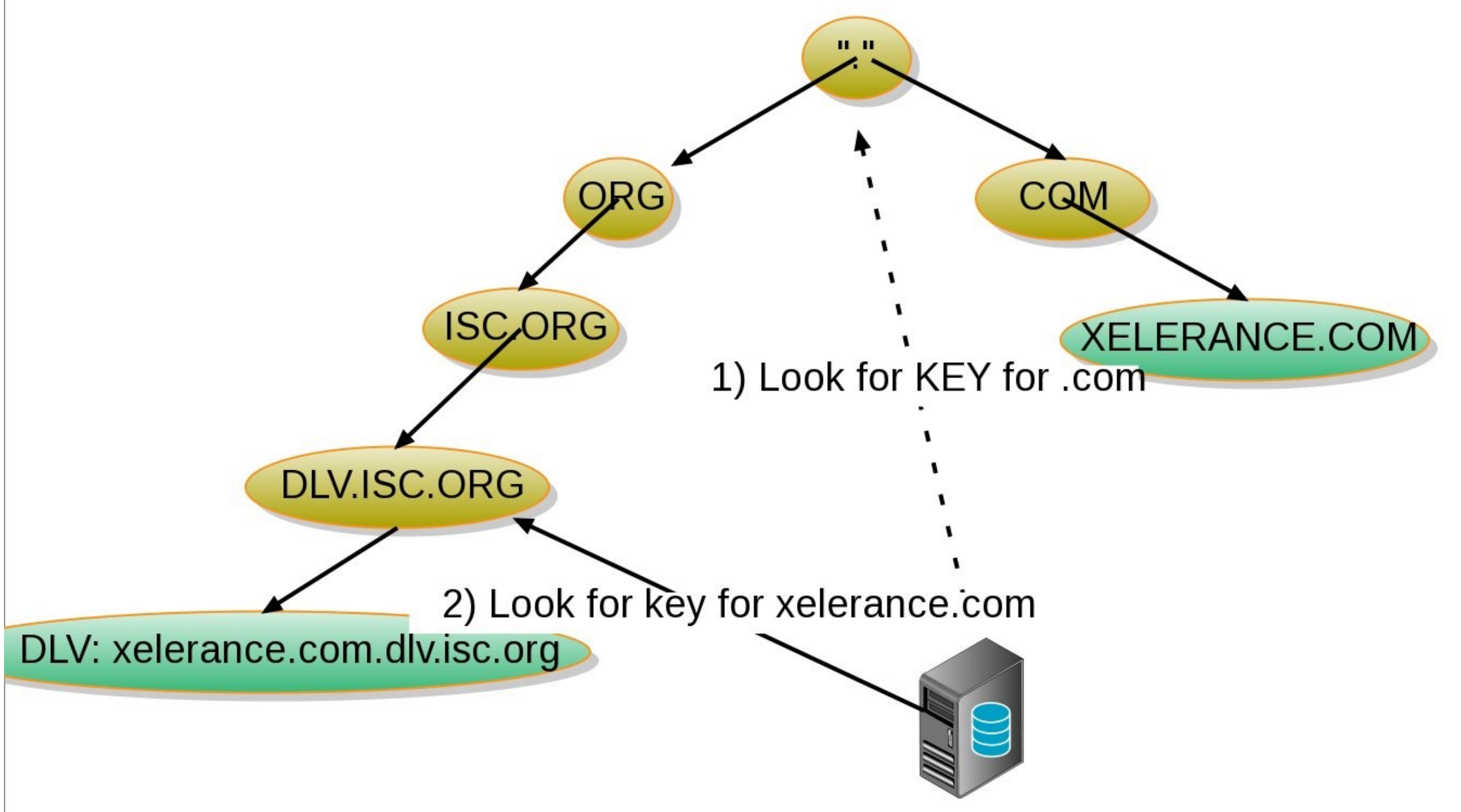
www.xelerance.com/dnssec/

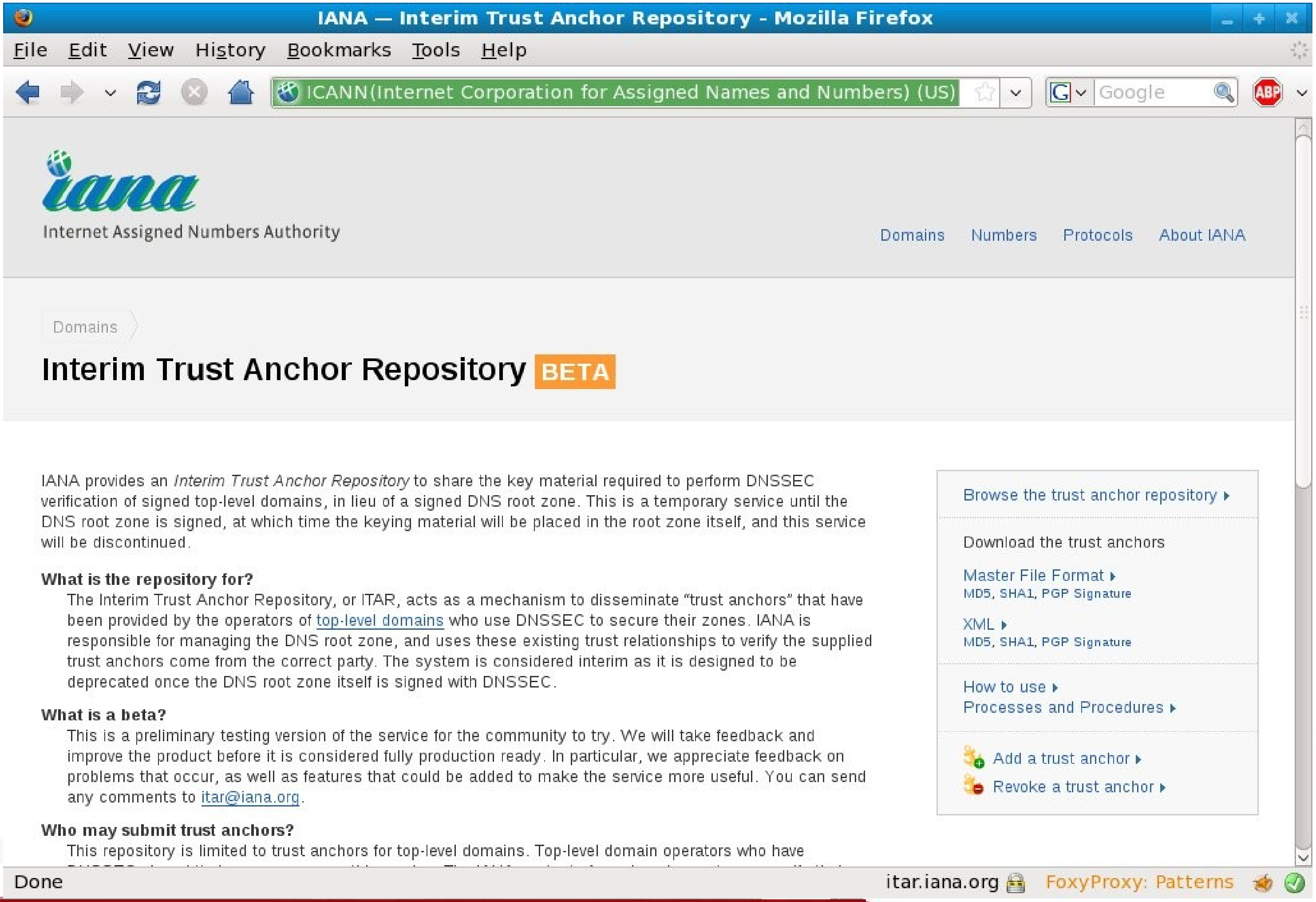


- TLD Production
- Reverse Production
- ccTLD Testbeds
- gTLD Testbeds
- DLV Registry
- Unofficial Projects
- Discontinued

DNSSEC Look-aside Verification



Feb 16: https://itar.iana.org/



.gov is signed!

DNSSEC for All Top Level .GOV Domains

Published: August 29th, 2008 | Category: Security Vulnerabilities

Last week the Office of Management and Budget released memoranda M-08-23, titled Securing the Federal Government's Domain Name System Infrastructure. The document states that all US government top level .gov domains will use DNSSEC starting in January 2009. This is in response to the DNS cache poisoning attack that Dan Kaminsky made public a few months ago.

> **New Policy**
>
> This memorandum addresses two important issues in following through with the existing policy and expanding its scope to address all USG information systems.
>
> A. The Federal Government will deploy DNSSEC to the top level .gov domain by January 2009. The top level .gov domain includes the registrar, registry, and DNS server operations. This policy requires that the top level .gov domain will be DNSSEC signed and processes to enable secure delegated sub-domains will be developed. Signing the to level .gov domain is a critical procedure necessary for broad deployment of DNSSEC, increases the utility of DNSSEC, and simplifies lower level deployment by agencies.
>
> B. Your agency must now develop a plan of action and milestones for the deployment of DNSSEC to all applicable information systems. Appropriate DNSSEC capabilities must be deployed and operational by December 2009. The plan should follow recommendations in NIST Special Publication 800-81 "Secure Domain Name System

www.govsecinfo.com

★ The Keys to Deploying DNSSEC: Managing and Meeting Your OMB Domain Name

Thursday, March 12, 2009

Session: 8:30AM - 4:30PM

Presented by:

DNSSEC

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

U.S. Department of Homeland Security

DNSSEC Development Coordination Initiative

The DNSSEC Deployment Initiative works to encourage all sectors to voluntarily adopt security measures that will improve security of the internet's naming infrastructure, as part of a global, cooperative effort that involves many nations and organizations in the public and private sectors.

dnssec-conf

www.xelerance.com/software/dnssec-conf

Provides key management and dnssec configuration for Fedora/RHEL/CentOS

Yum install dnssec-conf

dnssec-configure –dnssec=on –dlv=on

DNSSEC software

- Authoritative nameservers:
  - Bind - www.isc.org
  - NSD - www.nlnetlabs.nl/projects/nsd/
  - Microsoft DNS (support recordtypes, not signing)
- Recursive validating nameservers:
  - Bind - www.isc.org/bind/
  - Unbound - www.unbound.net

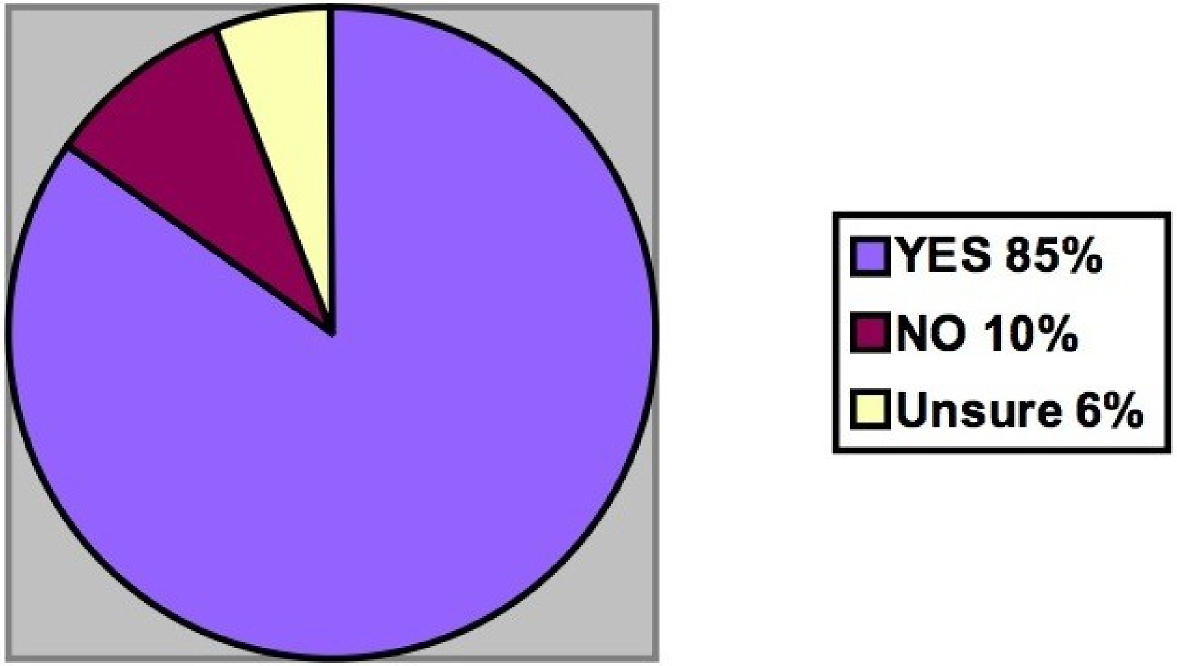
config-system-dnssec

TODO: Integration

- Integrate DNSSEC resolver with Network Manager
- Use DNS caching infrastructure via DHCP obtained DNS servers, but:
- Validate all crypto ourselves on the endnode

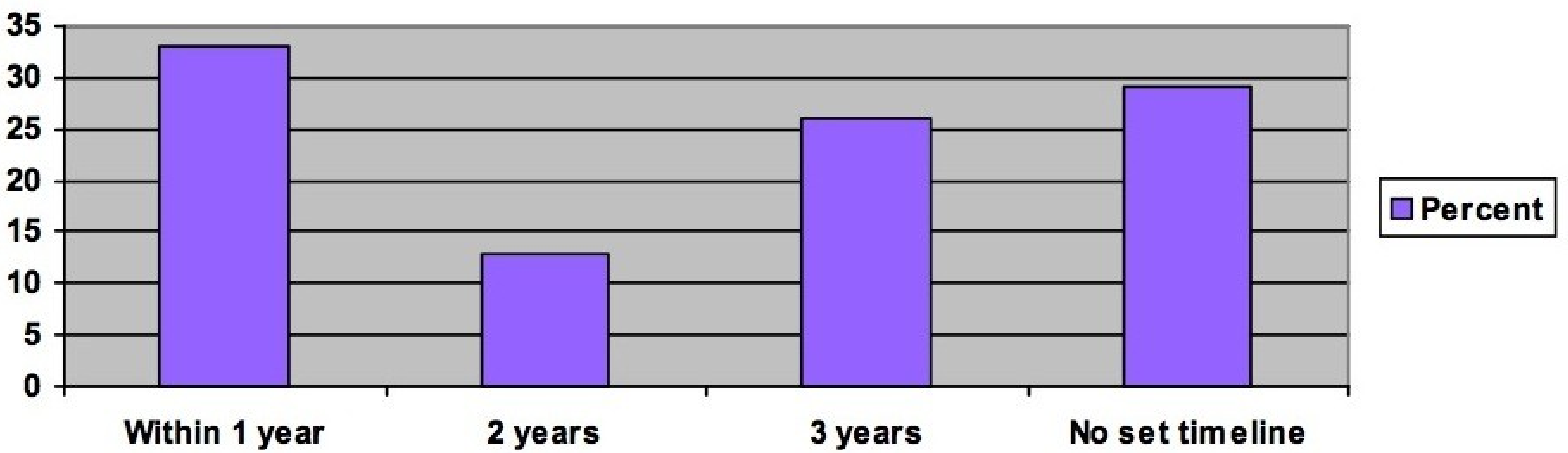
ccNSO survey Nov 2007

- If you have not implemented DNSSEC, are you planning to implement it?



ccNSO survey Nov 2007

If you have not implemented DNSSEC, when are you planning to implement it?



Conclusions (1)

Update your nameservers, or place them behind new nameservers.

Look into more software then just Bind

Unbound, PowerDNS recursor

Take a fresh look at your deployment, even when using firewalls and NAT. DNS **will** go through those.

Ditch DNS captive portals and broken DSL routers

Conclusions (2)

Prepare for DNSSEC

- **Tell your vendor[*] you require DNSSEC validation on your laptop using a DHCP obtained DNS caching server as forwarder.**

  [*] If you use Linux/BSD/OSX, why have you not installed/configured/enabled it yet?

Questions?

(feel free to test with nssec.xelerance.com)

Why DNSCURVE sucks

- There is no formal specification nor formal implementation, just proof of concept code
- Encrypts and protects TRANSPORT of dns data not data INTEGRITY itself
- Everyone has to bypass dns caches (or blindly trust them).
- Causes massive increase in DNS traffic
- Type overloading of NS records with long crypto keysas names (HACK)
- Uses patent encumbered Elliptic Curve cryptography
- Uses Bernstein's specifically picked homegrown elliptic curve
- No cipher or algorithm migration path if the curve falls over
- Uses 95% more CPU (on each query instead of once on a signer machine)
- Provides no partial deployment support (Secure Entry Points)
  - I still need to punch him in the face for qmail