Do not shun DNS

Code for Venezuela: San Francisco Hackathon 2019

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Domain Name System – DNS

. . . everyone ~~needs~~ depends on it.

- 30+ years going strong – RFC-1034 & 1035 (1987)
- Distributed global hierarchical database
- Optimized for searching **domain names**
  - Dot separated **labels** – `www.isc.org`
  - There's a dot at the end – it's there.
  - Case-insensitive
- Users query using UDP 53 – servers interact using TCP 53

From names to IP addresses,
and back again.

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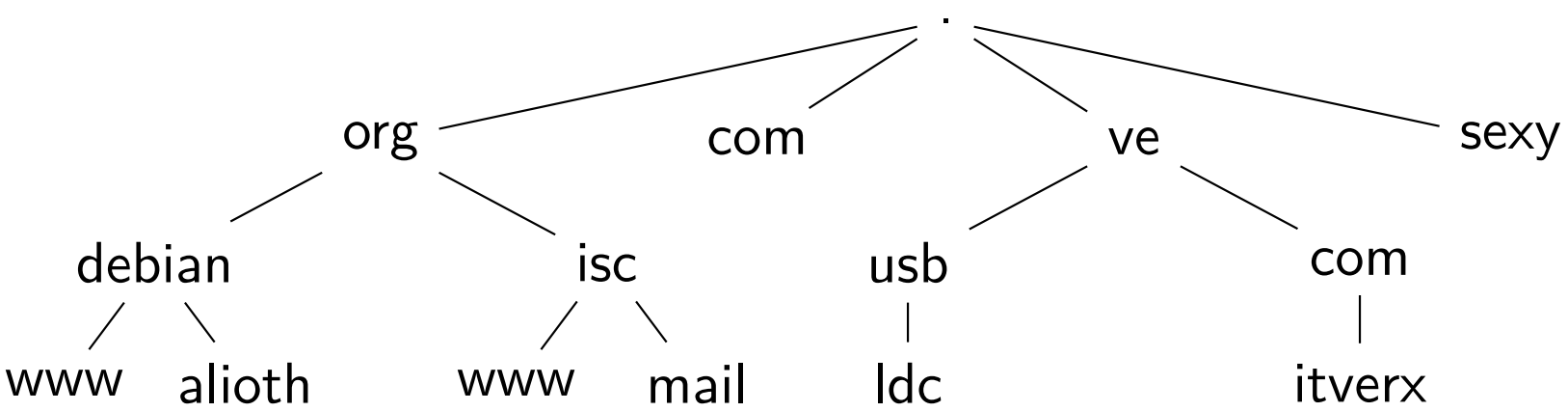
Distributed and global?

The name space is structured as a tree



- DNS is a tree of labels – can you spot the dot now?
- Labels are unique within sibling groups.
- Top Level Domains (TLDs) – .com, .net, .edu, .org
- Country Code TLD (ccTLDs) – .ve, .us, .ch
- Generic TLD (gTLDs) – .sexy, .tattoo, .link, .juegos, .sucks, . . .

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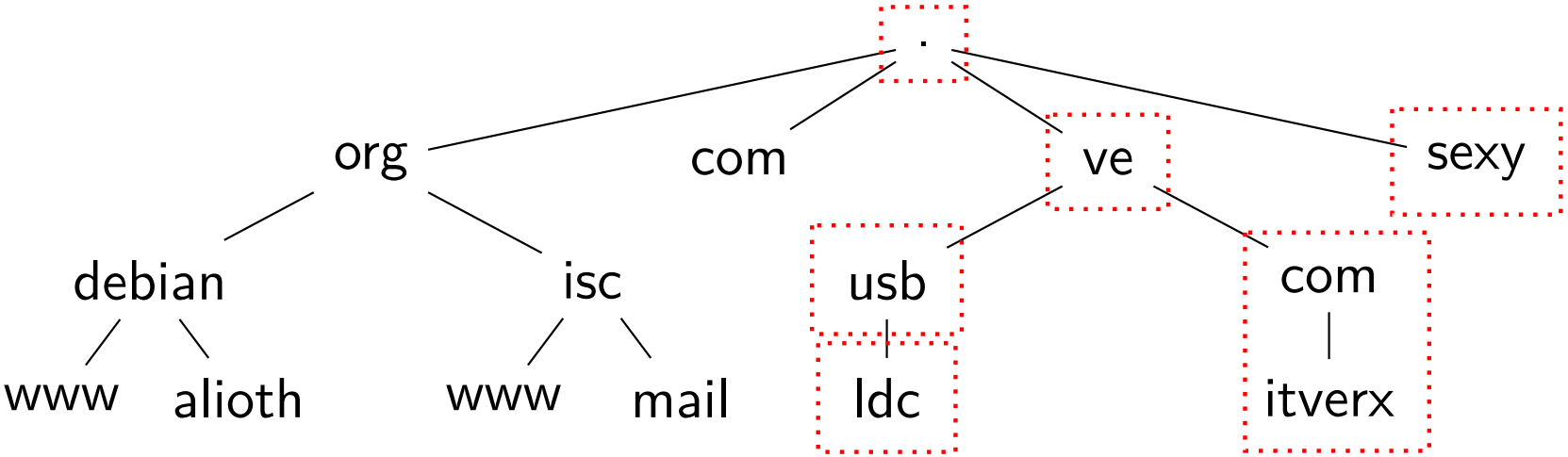
How is it distributed?

Names, domains and zones...



- Domain Name – traverse tree from label to root.
- Domain – any given node in the tree.
- Zone – a sub-tree under autonomous administration.
- Delegation – child node's zone different from parent's

Each domain has associated information.

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What kind of information?

Records, DUH!

- **Resource Records** – RRs for short
- Name, time to live, type, class, and actual resource.
- Hgh-performance binary representation with textual representation.

```
www.usb.ve.      86400 IN CNAME usb.dsm.usb.ve.
usb.dsm.usb.ve. 86400 IN A 159.90.210.22
usb.dsm.usb.ve. 86400 IN A 159.90.210.24
```

- A name can have several RRs, all with same TTL.

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Frequent RRs

New RRs are proposed and adopted when convenient

SOA	**S**tart **O**f **A**uthority
NS	Name Servers for zone
A	IPv4 address for name
AAAA	IPv6 address for name
MX	**M**ail **Ex**changer
SRV	Generic service locator (LDAP, XMPP, ...)
TXT	Plain text information

- Zone admin **must** add RRs for relevant names – each RR is valid for its TTLs (caching!)
- Users typically want the value associated with an RR

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How does it work?

There are Servers

- Servers in charge of a **zone**
  - One or more **authoritative** servers per zone.
  - They are listed as "official servers" for the zone.
  - One is the actual master – holds the database
  - The rest are replicas – they get notified and transfer changes.
- Delegated zones
  - Superior zone points to inferior (we call it glue).
  - The `root` zone points to servers for `com`, `ve`, `sexy`, `...`
  - Zone `ve` points to servers for `usb.ve`, `itverx.com.ve`, `...`
  - Zone `usb.ve` points to servers for `ldc.usb.ve`.

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Querying the database

This happens in your device

- There's a stub resolver on every OS – it's a library.
- Programs ask for a name to be "resolved" – desired RRs are returned, if they exist.
- Library needs access to a recursive server.
  - Receives queries for any zone.
  - Follows the delegation chain to find authoritatives.
  - It caches the answer for future reference.
- What recursive is going to be used?
  - Usually provided via DHCP from your ISP or network administrator.
  - Can always be changed to a better one – for many notions of "better"

But why ~~would~~ should you change it?

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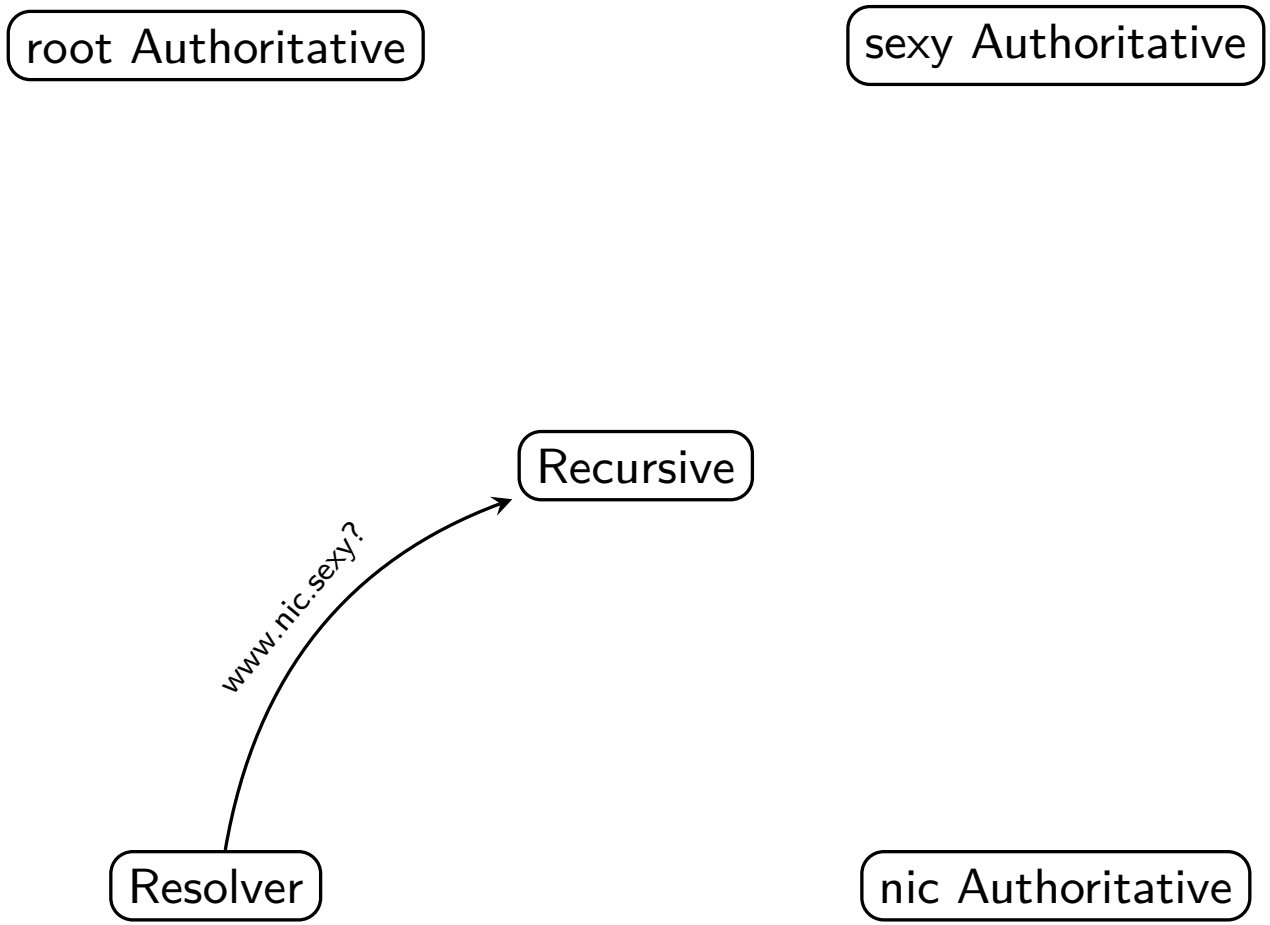
A recursive query

What's `www.nic.sexy` IP address?



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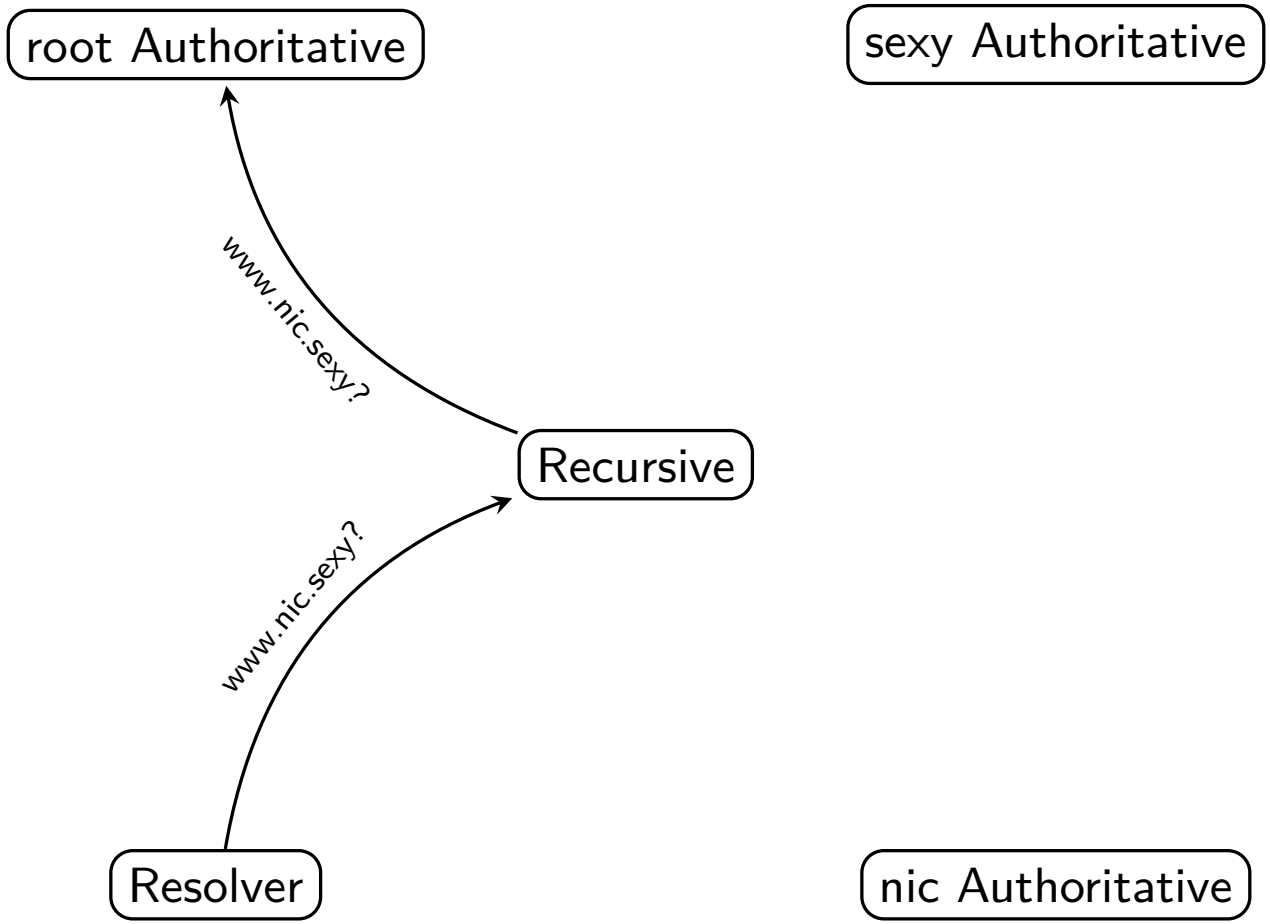
A recursive query

Recursive alwways queries `root`



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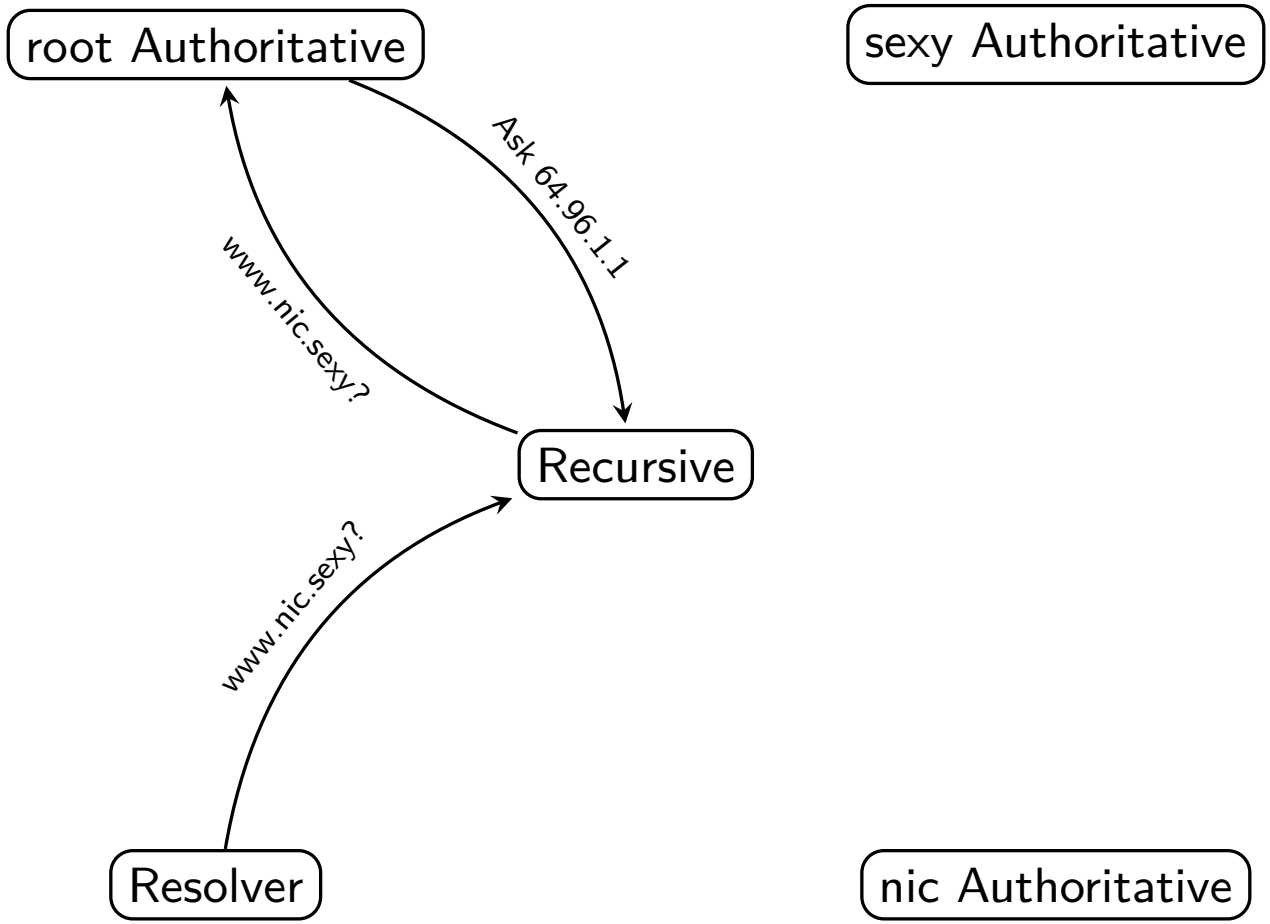
A recursive query

`root` refers to `sexy` authority



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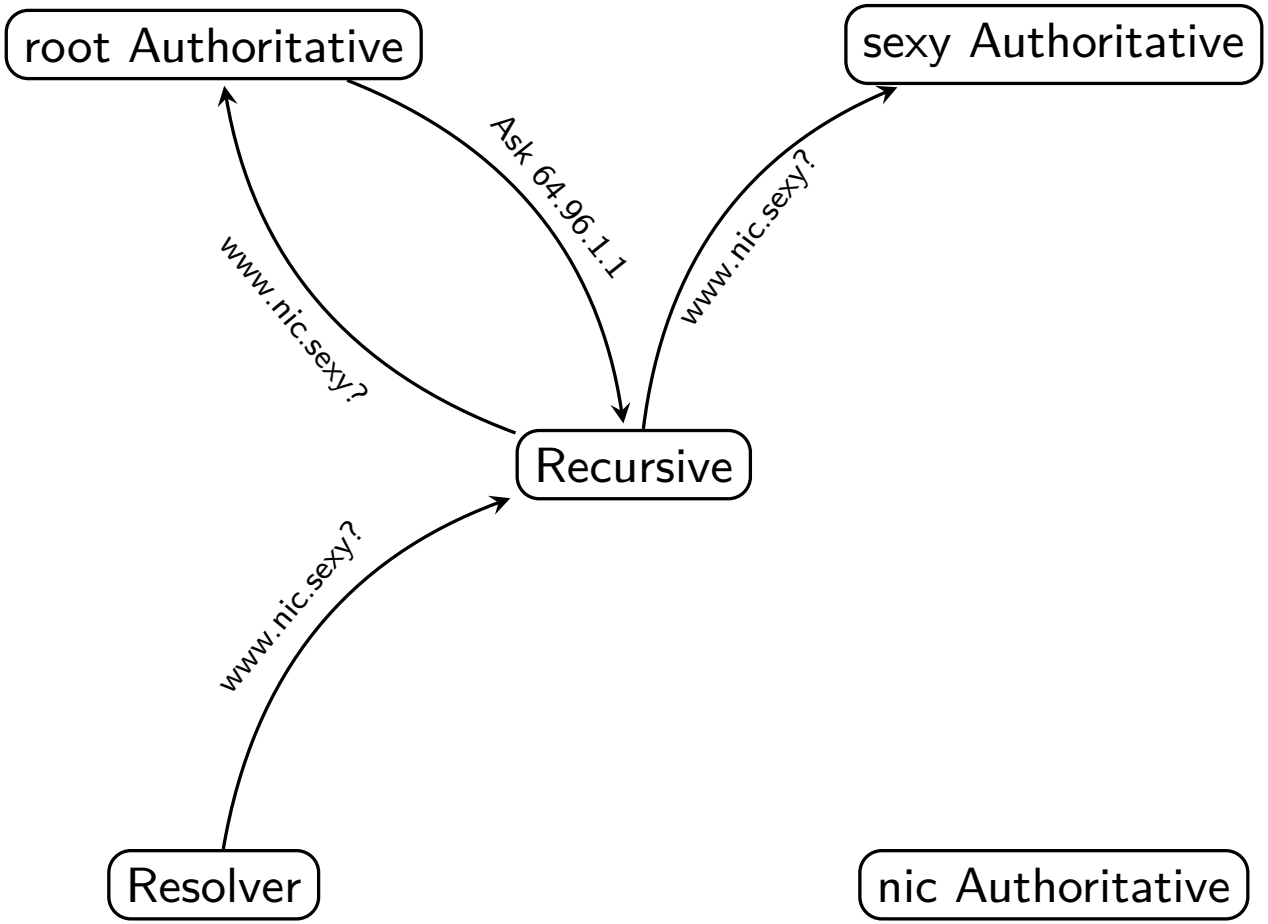
A recursive query

Recursive queries `sexy`



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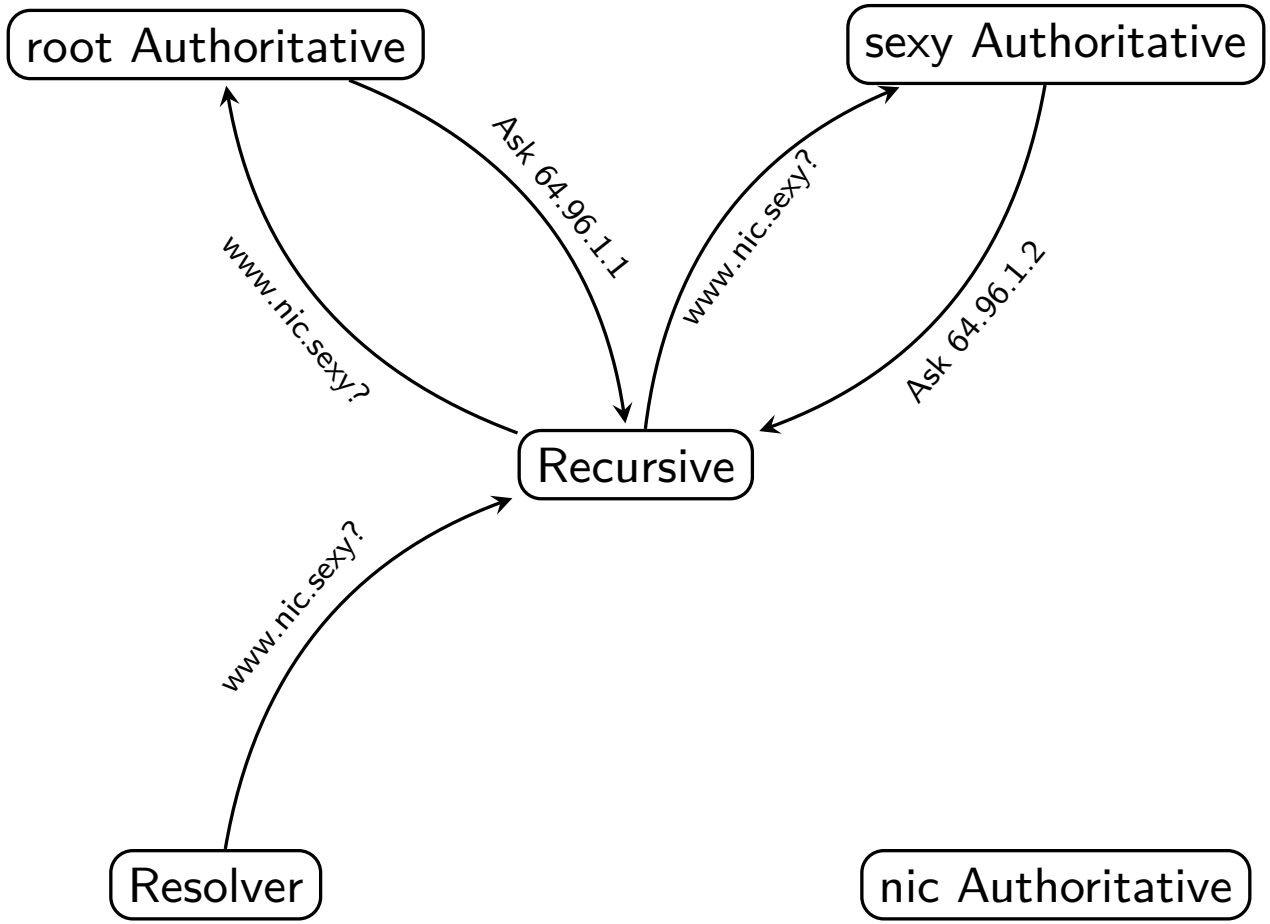
A recursive query

`sexy` referral to `nic.sexy`



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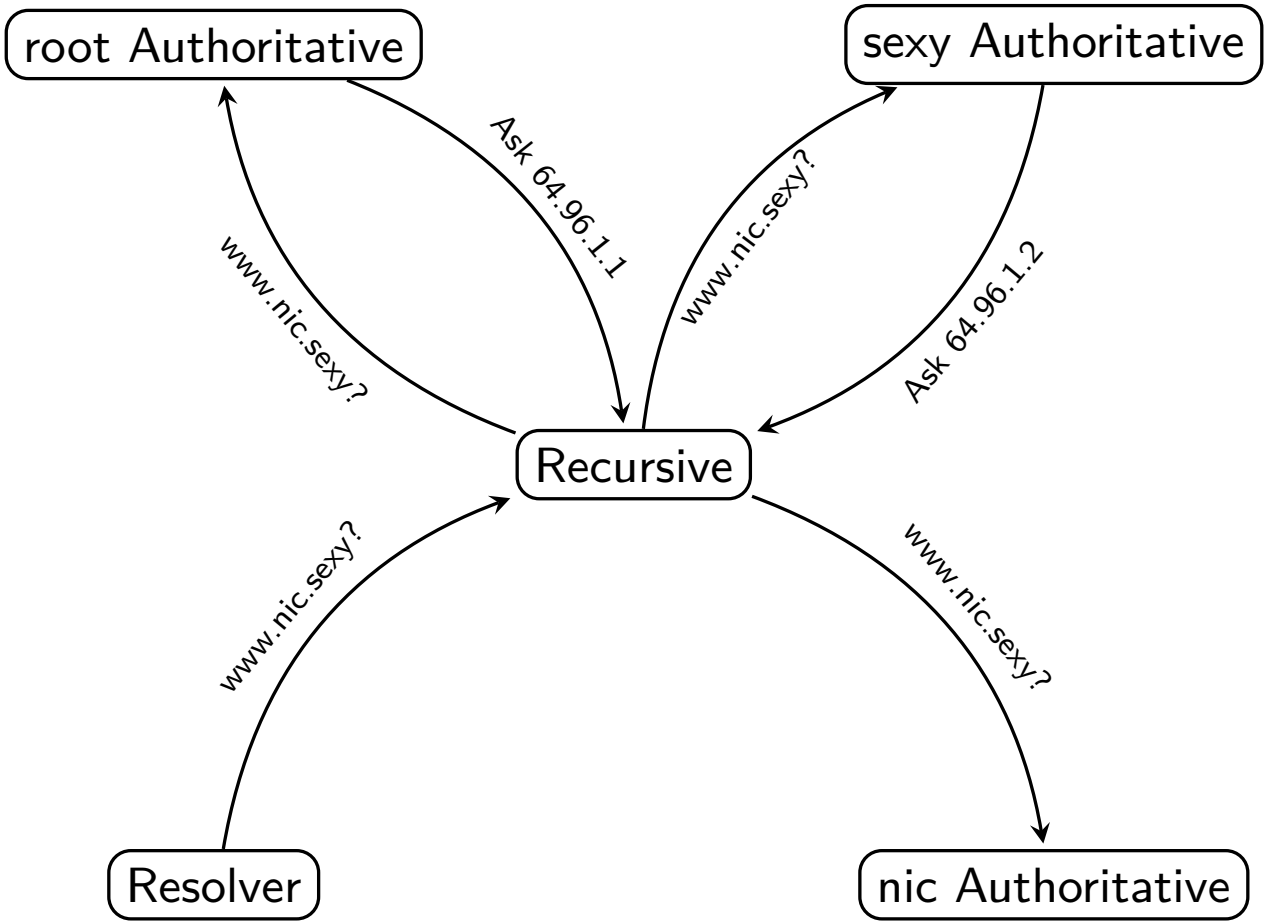
A recursive query

Recursive queries `nic.sexy`



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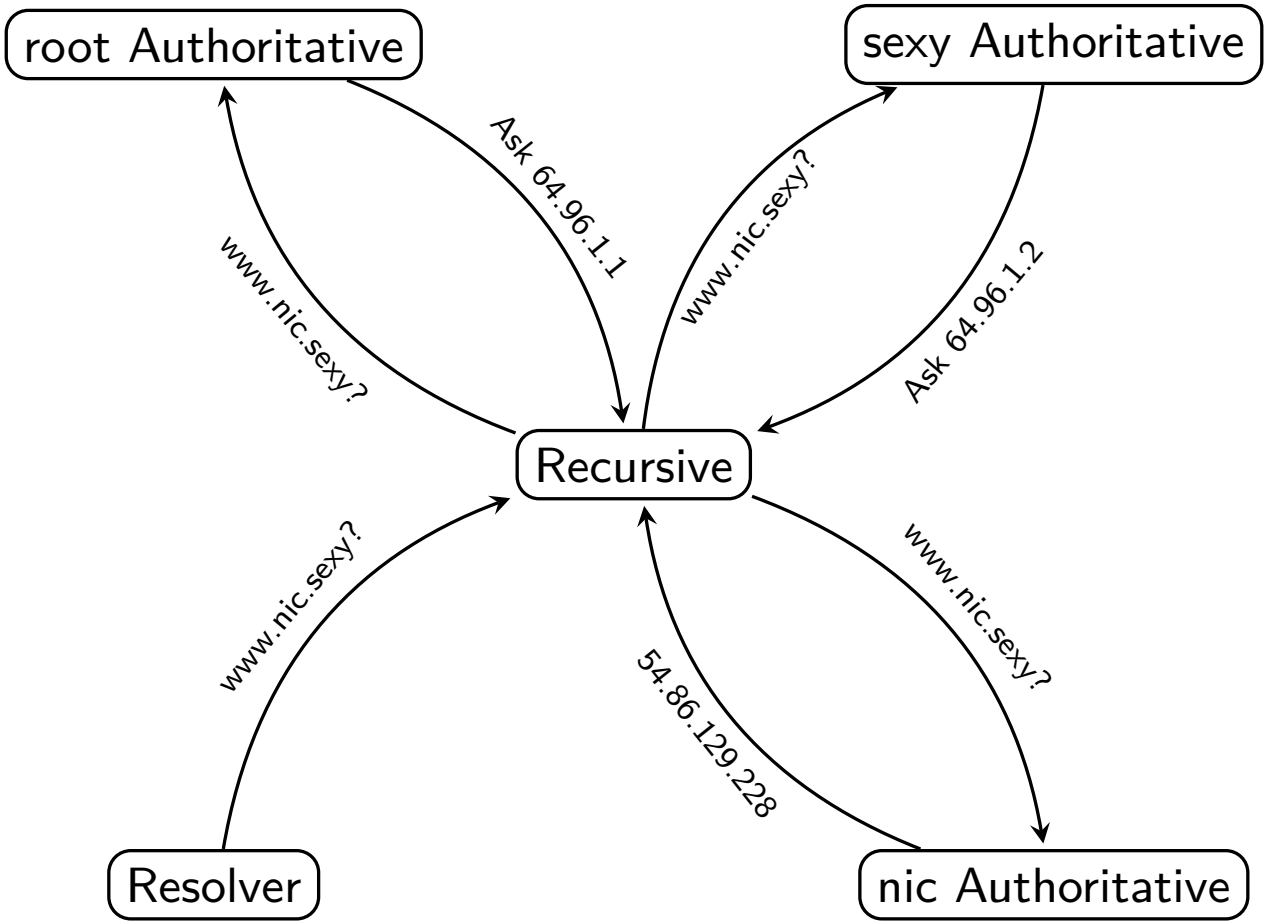
A recursive query

`nic.sexy` answers with authority



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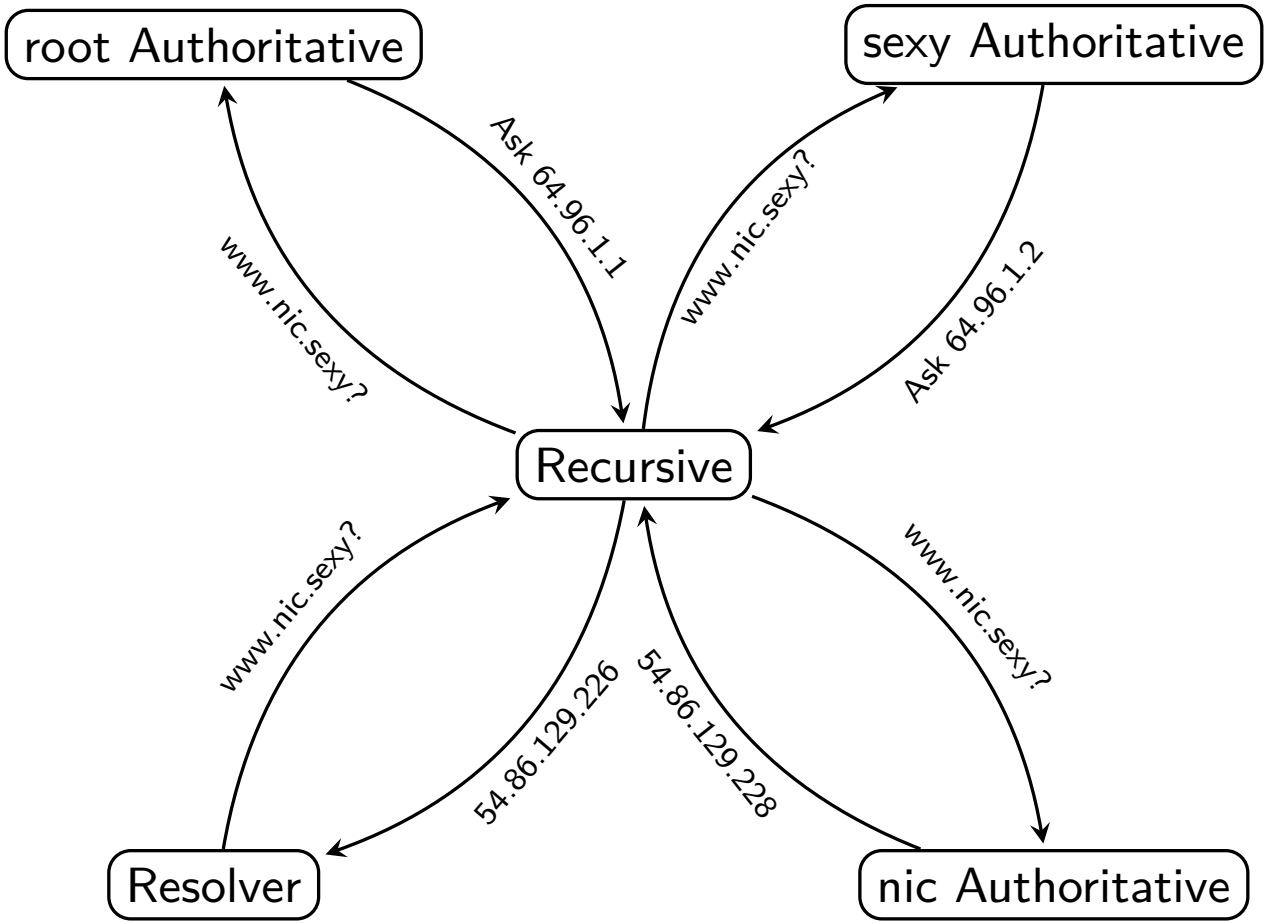
A recursive query

Recursive relays answer to your device



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A recursive query

Keep in mind...

- There could be many answers for each query –
  more than one NS per zone, more than one IP per name...
- Queries happen over UDP – packet loss, congestion
- Recursive caches every answer locally –
  further queries are satisfied from the cache.
- Answers expire after the TTL – recursive purges cache.
- Failed queries are **also** cached.

Recursive servers are crucial.

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Things can go very bad

“Total, la gente, ¿qué sabe?” – Les Luthiers

- Most users couldn’t care less about DNS –
  invisible, hasn’t got a flashy UI, no BlueTooth®...
- But everyone **depends** on DNS – no DNS, no Internet for you!
- Most failures were due to poor network administration
  - Missing, incorrect, or contradicting RRs.
  - Not having replicas or having out of sync replicas.
  - Not enough authoritatives nor recursive servers.
  - Incomplete or incorrect delegation.

But as a user, you rely on recursives,
and you should be very, **VERY** afraid...

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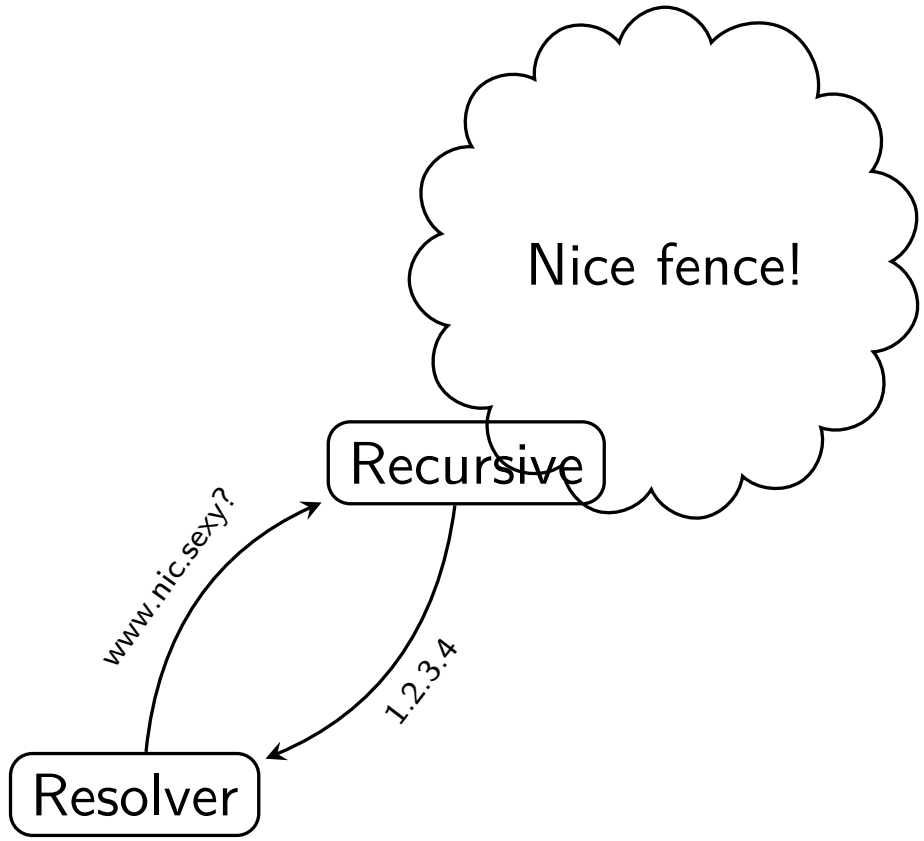
Who controls the recursive?

Do they have a clue? Are they trustworthy?

- You get answers from the recursive – you have **no way** to know if it traversed the hierarchy correctly and completely.
- Is the answer **true and legitimate**?
- Is the answer **complete?**
- Is the negative answer **proof** of absence?



People: use a different recursive!

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Never use “bad people’s” recursives

. . . they could be trying to trick me or plain stupid

- “Use Google’s!” – 8.8.8.8
- “Use CloudFlare’s!” – 1.1.1.1
- “Use OpenDNS’!” – said the hipster. . .
- “Use your Access Point’s!” – expanding brain meme
- “Setup your own recursive!” – expanding brain meme

Anything but “those people’s” recursive, right?

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Using a different recursive is not enough

. . . because you have to go through the ~~fence~~ swamp

- Let's say you expanded your brain
  1. Your device uses your alternate recursive.
  2. A filter within the ISP detects the query – easy peasy.
  3. The filter forges an answer or behaves as authority.
  4. Your query never reached the recursive – brain explodes.
- That's a classical "man in the middle attack" (MITM).
  - Forging answers so you're directed somewhere else.
  - Making it look like a failure or unavailable site.

The fence between client and external recursives is hostile.

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But using mine is safe, right! Right?

. . . yeah, right, except when rarely ever

- So you setup your local network recursive with Linux or FreeBSD.
- Someone in the network could be doing exactly the same – can't deny nor confirm it was me.
- But let's assume I'm not doing that for the sake of argument
  1. Your device queries the recursive.
  2. The recursive queries the root – a filter within the ISP notices it.
  3. The filter follows the query sequence until the end.
  4. The filter changes the last answer to whatever ~~I want~~ it wants.
- Your cache's been poisoned
  - Forging answers, making you go elsewhere.
  - Making it look like failure or "blocking".
  - . . . but this time is worse – it will have a long TTL within your cache

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DNSSEC – Domain Name System Security

Extension to traditional DNS

Guarantees

- Answers you receive are **authentic**
- Answers you receive are **unmodified**
- Negative answers really mean a non-existent name.

Does not guarantee

- Query/answer **confidentiality**
- DoS protection

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DNSSEC - General idea

Some assembly required. Batteries not included.

- Asymmetric criptography
- Zone admin signs RR with the private key.
  - Zone cryptographically signed as a whole.
  - Each RR has its own signature.
- Public key included with the zone.
- Recursives are able to **check** answers using the public key.
- The chain of delegation builds a chain of trust.
- This requires a lot of new RRs.

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And here they are

Good system design included ways to extend DNS itself

DNSKEY	Zone Public Key
RRSIG	Digital signature for RR
NSEC	Next name – to verify non-existance
DS	Delegation signature – child zone fingerprint

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Zones grow complex

. . . but trust increases

- One or more **DNSKEY** for different purposes
  - **KSK** – strong private key to sign other keys
  - **ZSK** – strong private key to sign the zone
  - The **KSK** signs the **ZSK**.
- One or more **RRSIG** for each RR set per name – signature plus validity.
- One or more **NSEC** per name
  - Points to the next signed name
  - Jump over "holes" – identifies non-existing names.
  - It's a circular list starting and ending at the SOA.
- One or more **DS** from parent to child zone.
  - Adult supervision required – parent zone must cooperate.
  - Parent zone confirms valid keys for child zone.

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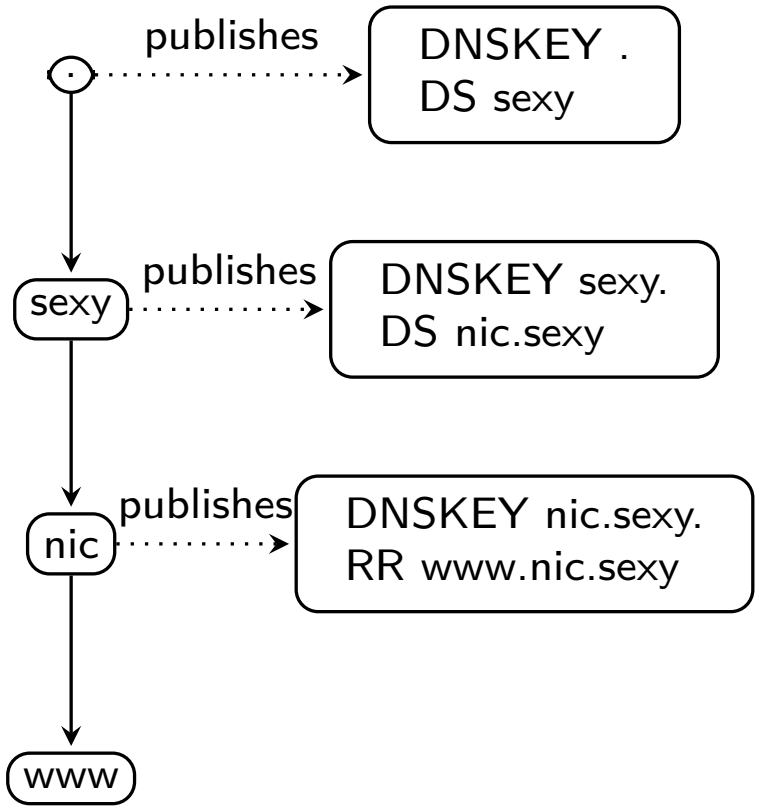
The chain of trust

Built on top of delegation, rooted on ICANN's trust

- Root zone (.) hols DS records for every TLD using DNSSEC – publishes a DNSKEY to check those DS.
- Each TLD zone (`sexy`) holds DS for delegated zones – publishes its own DNSKEY to check those DS.
- Final zone (`nic.sexy`) publishes a DNSKEY.
- RR for (`www.nic.sexy`) is signed (RRSIG) – checked with `nic.sexy`'s DNSKEY



A recursive can perform those checks.

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What's the end result?

We can demand `dig` to validate DNSSEC – heavily edited for human consumption

```
$ dig +dnssec www.nic.sexy
...
;; flags: qr rd ra ad; QUERY: 1, ANSWER: 2, AUTHORITY: 5, ADDITIONAL: 1
...
; EDNS: version: 0, flags: do; udp: 512
...
;; ANSWER SECTION:
www.nic.sexy.   3599  IN  A 54.86.129.228
www.nic.sexy.   3599  IN  RRSIG A 5 2 3600
 20190423204035 20190324194943 15813 nic.sexy.
 ZfSyTWXRrArz8LKXLeCP5eXau
 4j4eDAdHmHxrQJKqIJG+5H2BKs84dLN ZxfLssf+Ua5Lp8Q2+5v7iU41
 J0F2egmGKMstpm+nQ8Xbhmc3sxZsmluW VpzcOeQs7FCVX5VNE307tKV7A4kHcavkb61LEO/sD7Z8faJK2
```

- Authentic answer – flag **ad**.
- Untampered answer – flag **do**.
- RRSIG shows date validity ranges.
- NS RRSIGs omitted – more confirmation the name is valid.

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What if we query an unexistent name?

Make sure it does not exist

- "Certifiably unexistent" – zone holds "existing" names only.
- Names can be ordered (discrete math sends his regards!) – there is a "hole" where names are missing.
- NSEC (Next Secure) RRs fill these holes – point to the next **existing** name.
  - Querying and unexistent name using DNSSEC will answer with predecessor and successor names – yes, an information leak!
  - NSEC3 improves by using hashes instead of plain names.

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Got it! What do we need to do?

Be aware, be able to explain, be able to guide

- Stop relying on third-party resolvers, specially those than can be compromised (like those within CAN'TV).
- Deploy your own resolvers, forcing DNSSEC.
- Deploy your applications on domains served using DNSSEC.
  - Choose a TLD that supports DNSSEC.
  - Choose a Registrar that supports DNSSEC.
  - Use a DNS service provider supporting DNSSEC.
- Write your applications to look for names using DNSSEC and be very loud when unavailable – let the user now the name is not safe to use.
- Be wary of using any network service (webpage, API, e-mail) operating on a domain that is not DNSSEC-validated.
  - Doesn't matter if the service is TLS-encrypted.
  - Hijacking is easier with «Let's Encrypt» and no-DNSSEC.

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I need DNSSEC in my life

I need more cowbell

- I want **my zones** to be DNSSEC signed –
  deploy DNSSEC-aware **authoritative** servers.
  - BIND 9.10 or later – found in any Linux/FreeBSD.
  - Have several replicas in multiple geographic regions –
    protect replication using TSIG signing.
  - **Complexity** – key management, delegation, on-the-fly signing, ...
  - Pay for the service – ask the guy talking.
- I want my queries to **other zones** to enforce DNSSEC–
  deploy DNSSEC-aware **resolvers** on **your side** of the fence.
  - You can use BIND too, but **unbound** is way easier.
  - Enforce DNSSEC on the recursive.
  - Have your devices use that recursive instead.
  - Deploy this on local network – this is the tricky part.

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How about my non-tech savvy loved ones?

. . . 'cause they still think 8.8.8.8 is a good idea

- Do they have an Access Point at home/office?
  - Install FOSS-based firmware like DD-WRT or OpenWRT.
  - Use the embedded resolver supporting DNSSEC.
  - Bonus – pump up the antennas power beyond FCC regulations.
  - Idea – have local events to "upgrade" home AP devices this way.
- DNSSEC Validator – browser plugin, close but no cigar.
- AFAIK iOS/Android don't have DNSSEC support –
  it would be useful to make Unbound run on iOS/Android

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Assorted challenges

- What are Venezuela's ISP-provided resolvers?
- Do they allow DNSSEC-enforced queries?
- Do they give back consistent answers for any given name (DNSSEC-signed or not)?
- Are they faking authority for any given name (of course some are, which ones?).

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Is that enough?

Final thoughts

- DNSSEC is deployed on the assumption that noone wants to shutdown DNS, just manipulate it.
- DNSSEC does not hide information – it prevents tampering.
- ISPs can simply drop your queries – they could block you from using port 53 altogether.
  - Newcomers – DNS over TLS and DNS over HTTPS
  - DNS over TLS relies on port 853 – easily blocked.
  - DNS over HTTPS – browser centric (Danger, Will Robinson!)
- The artesanal solution I'm about to explain, but will not write in the slides to make it hard on the censors.

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There's a LOT to read...

- DNS – RFC-1034 y RFC-1035
- DNS – RFC-4033, RFC-4034 y RFC-4035
- DNSSEC TOOLS – http://www.dnssec-tools.org/
- BIND – Best name server for DNSSEC
  https://www.isc.org/downloads/bind/
  `apt install bind9 bind9-doc bind9utils`
- unbound – Compact recursive server with DNSSEC support
  http://unbound.net
  `apt install unbound`

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How many zones are using DNSSEC?

TLDs are covered, but operators are slow

- ICANN publishes a report on DNSSEC deployment
  http://stats.research.icann.org/dns/tld_report/
- Today 2019-04-13 at 12:07 PST – yes, I was working on slides...
  - 1398 out of 1531 TLDs are signed – 91 %
  - 1387 out of 1398 TLDs hold DS – 99 %
- **Every** new gTLD is signed and holds DSs –
  no wonder: it's mandatory as per ICANN's SLA.
- **Every** classical TLD (`com`, `net`, `org`, ...) is signed and hold DSs –
  if your domain is not being signed, ask your DNS administrator, your Registrar, and ultimately your Registry

`.ve` is not signed, doesn't have provisions for DNSSEC

(and WHOIS been broken for over five years, a different story...)

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Quid quid latine dictum sit, altum videtur.

¡Gracias!

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