DNS Privacy

dnsprivacy.org

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July 2017

Overview

- **The problem:** Why Internet privacy and DNS Privacy are important (DNS leakage)
- **Recent Progress:** Chart progress during last 3-4 years (DPRIVE) in open standards and open source software
- **Where are we now?** Present current status and tools

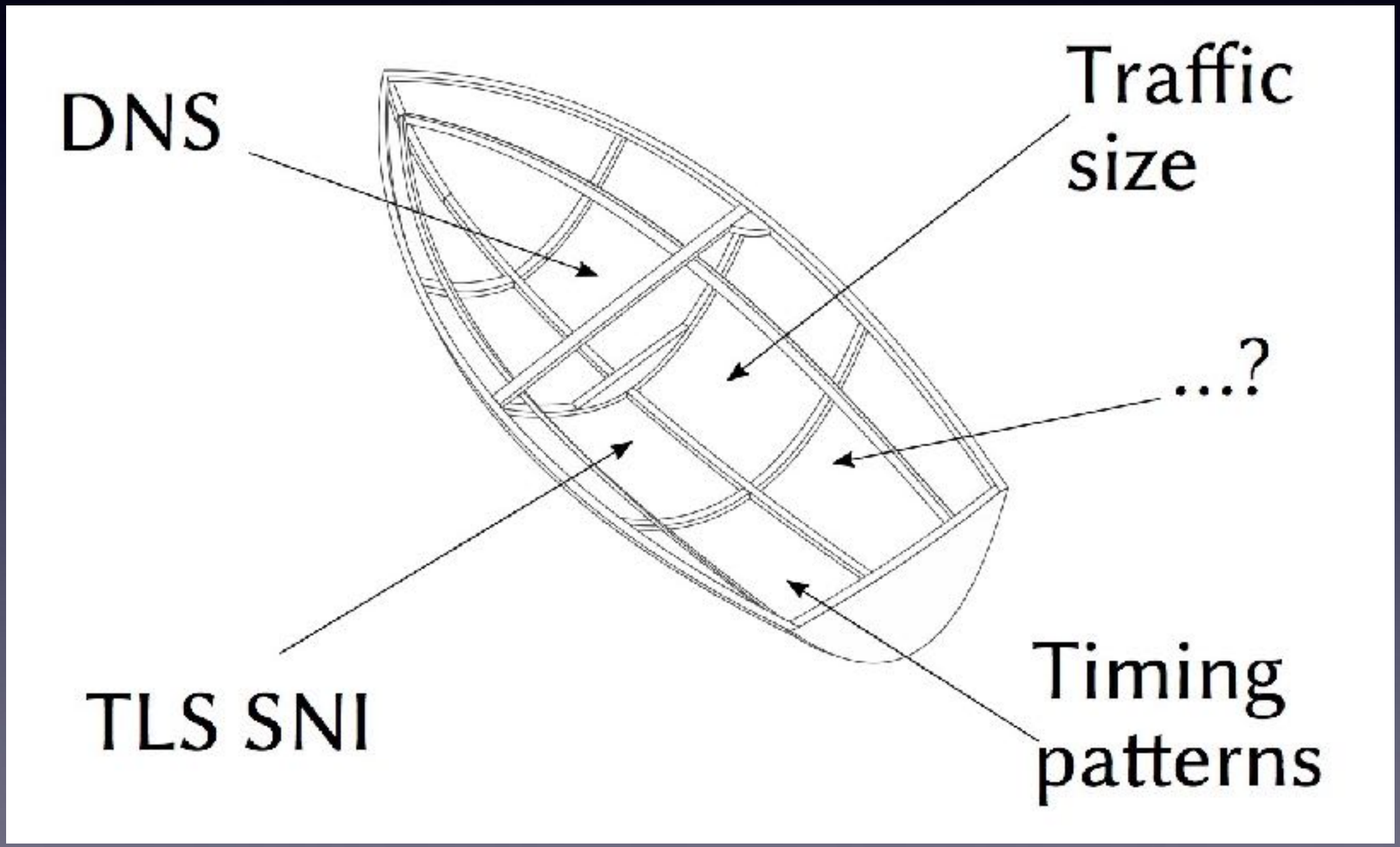
IETF Open Standards and Privacy

March 2011	**I-D:** Privacy Considerations for Internet Protocols (IAB)
June 2013	 Snowdon revelations What timing!
July 2013	**RFC6973:** Privacy Considerations for Internet Protocols
May 2014	**RFC7258**: Pervasive Monitoring is an Attack: "**PM is an attack on the privacy of Internet users and organisations**."

DNS Privacy

- A brief history

DNS is part of the Internet ‘leaky boat’ problem

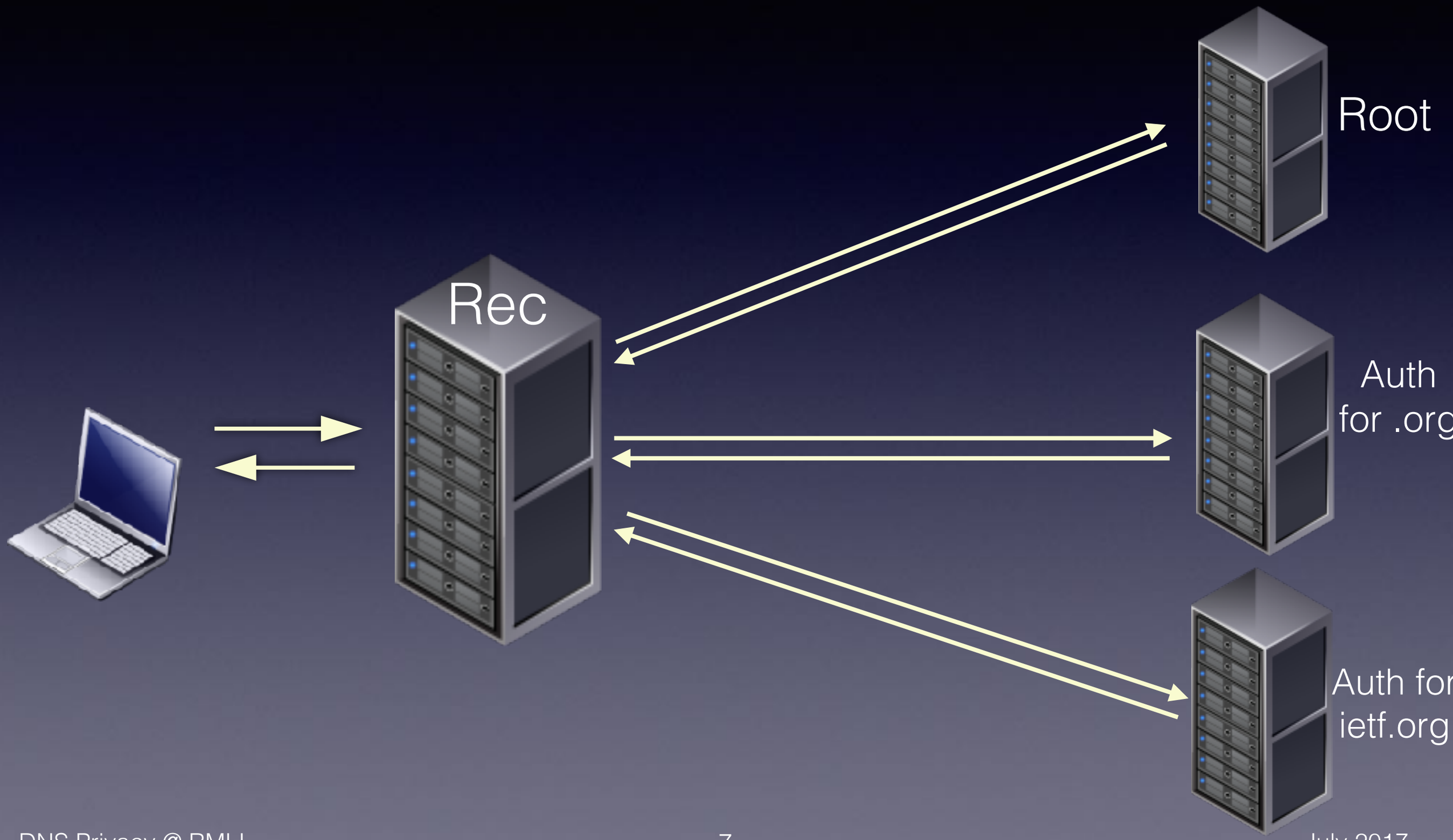


DNS Privacy (in 2013)

- DNS is 30 year old! [RFC1034/5 (1987)]
  - Original design: availability, redundancy and speed!
    - DNS is an ‘enabler’
  - DNS standards:
    - UDP (99% of traffic to root)
    - TCP only for ‘fallback’ (pre 2010)
  - Perception: The DNS is public, right? It is not sensitive/personal information….it doesn’t need to be protected/encrypted

DNS sent in clear text
NSA: **MORECOWBELL**

DNS Disclosure Example 1



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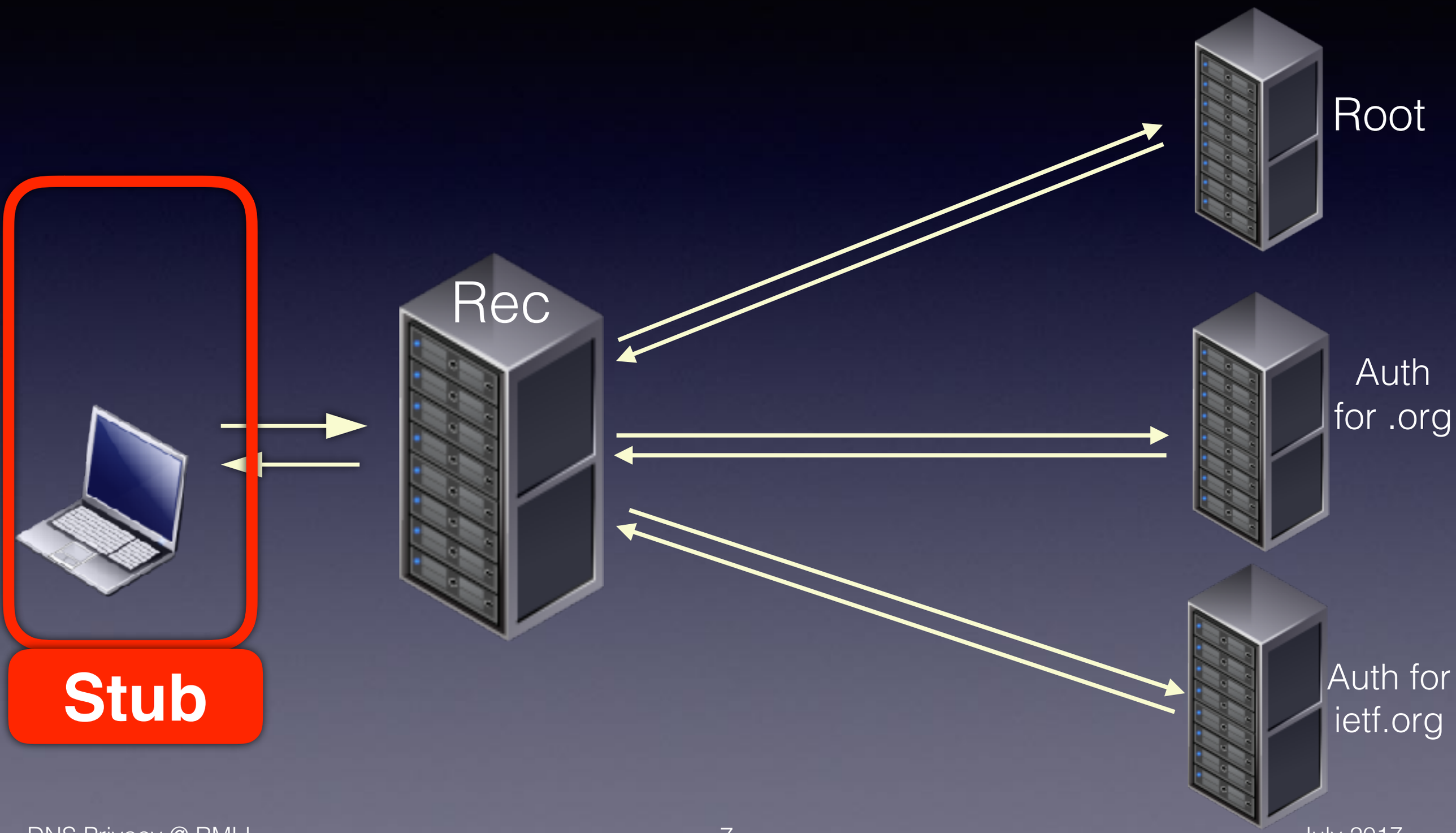

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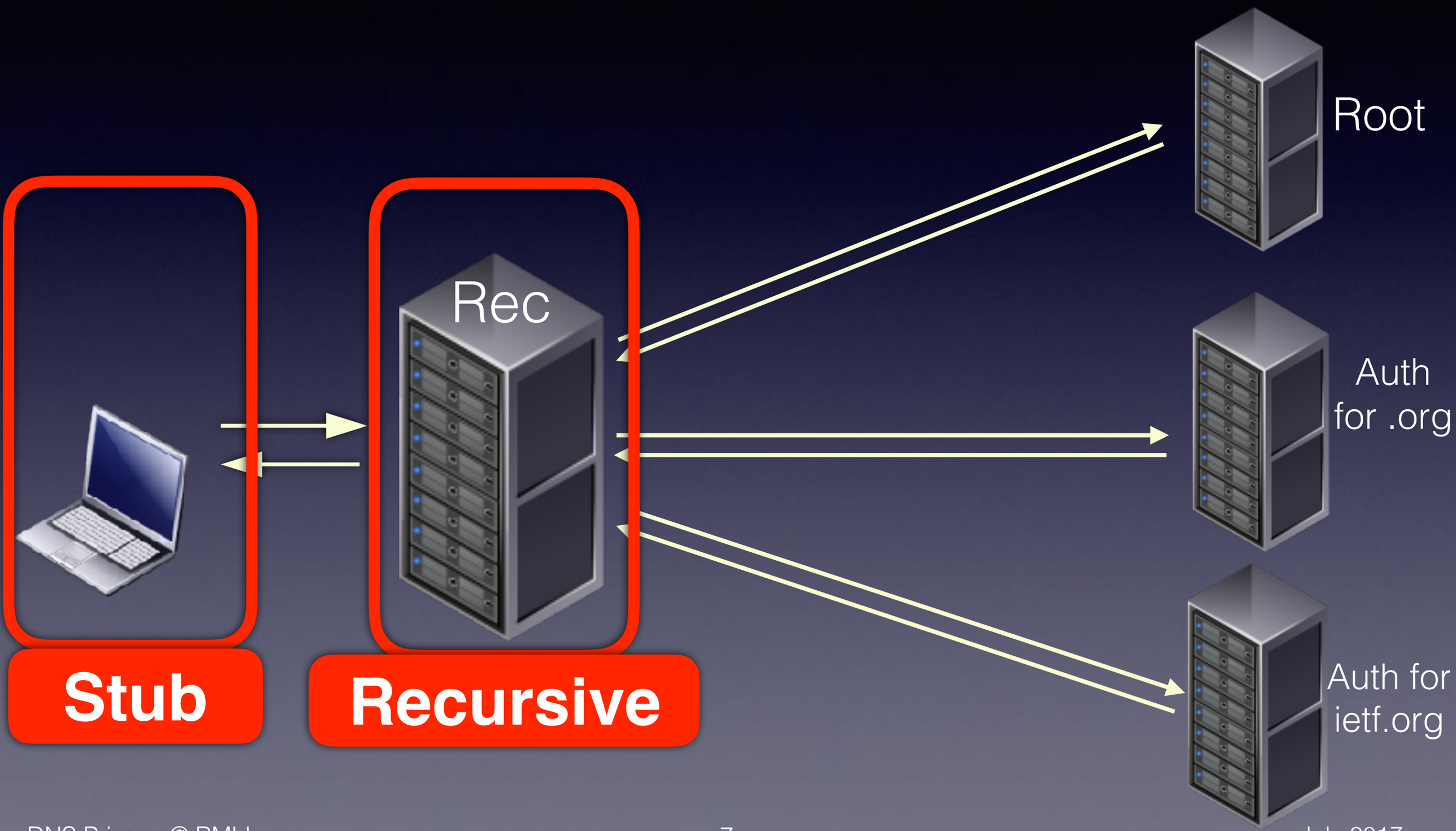

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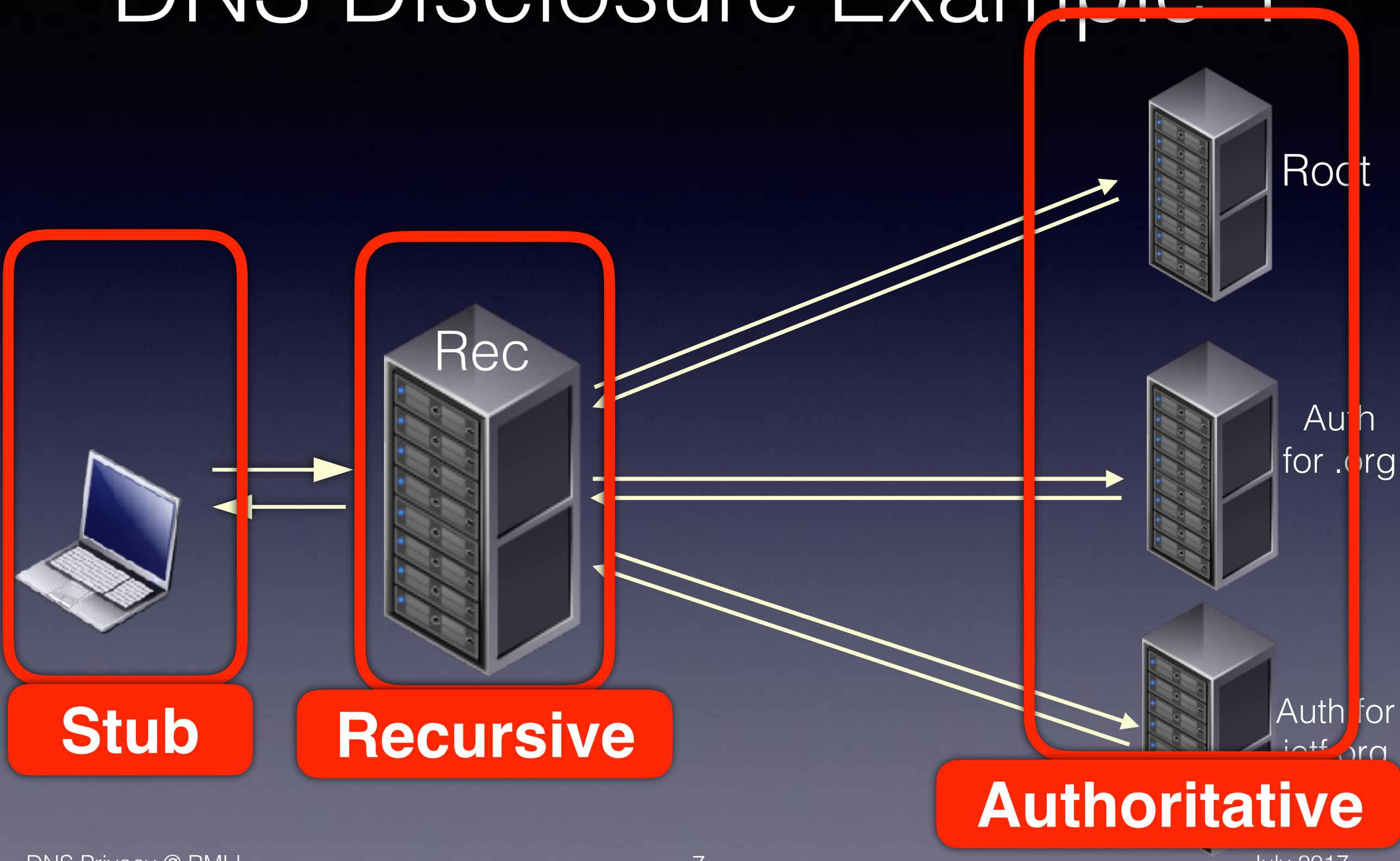

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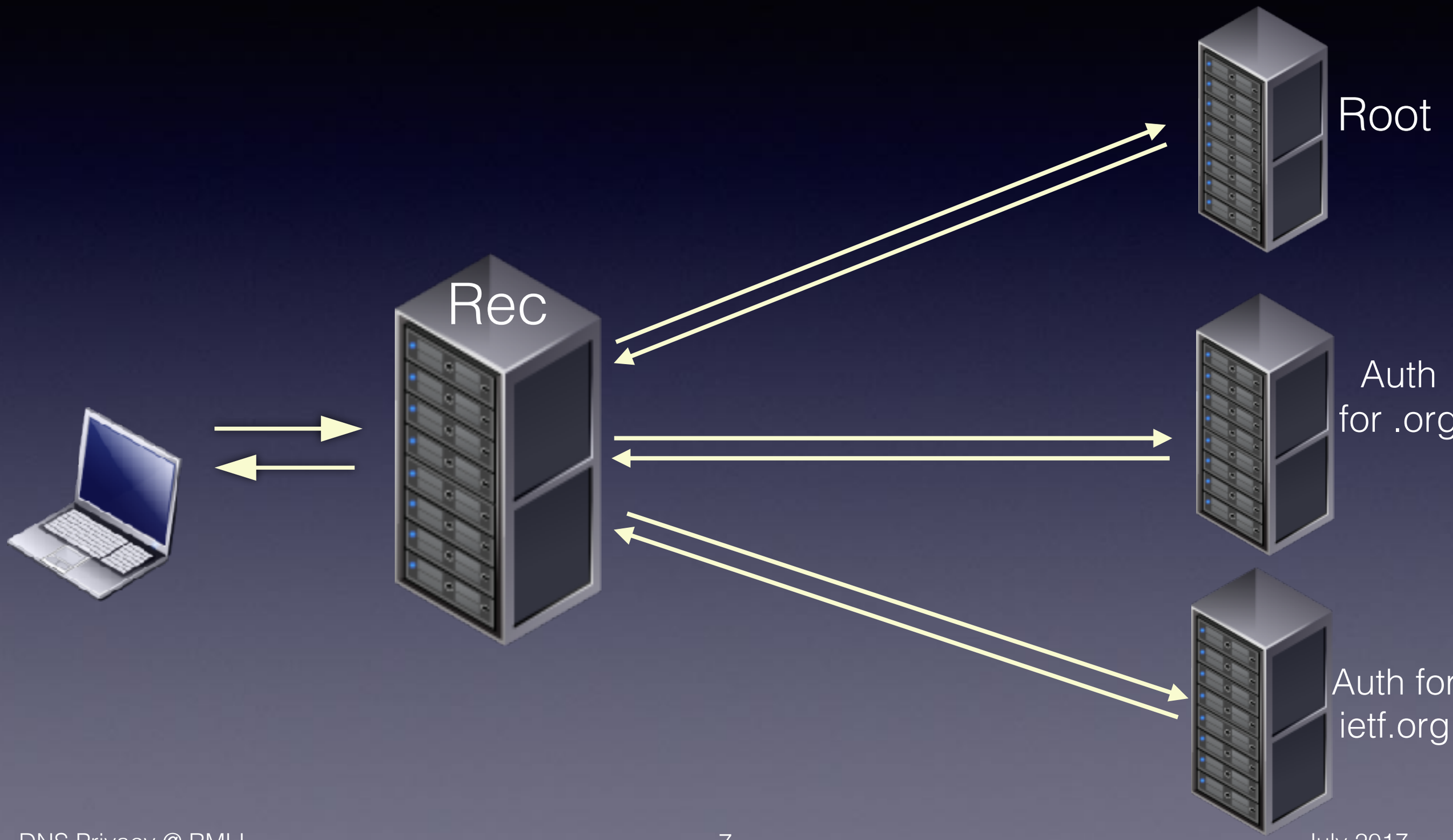

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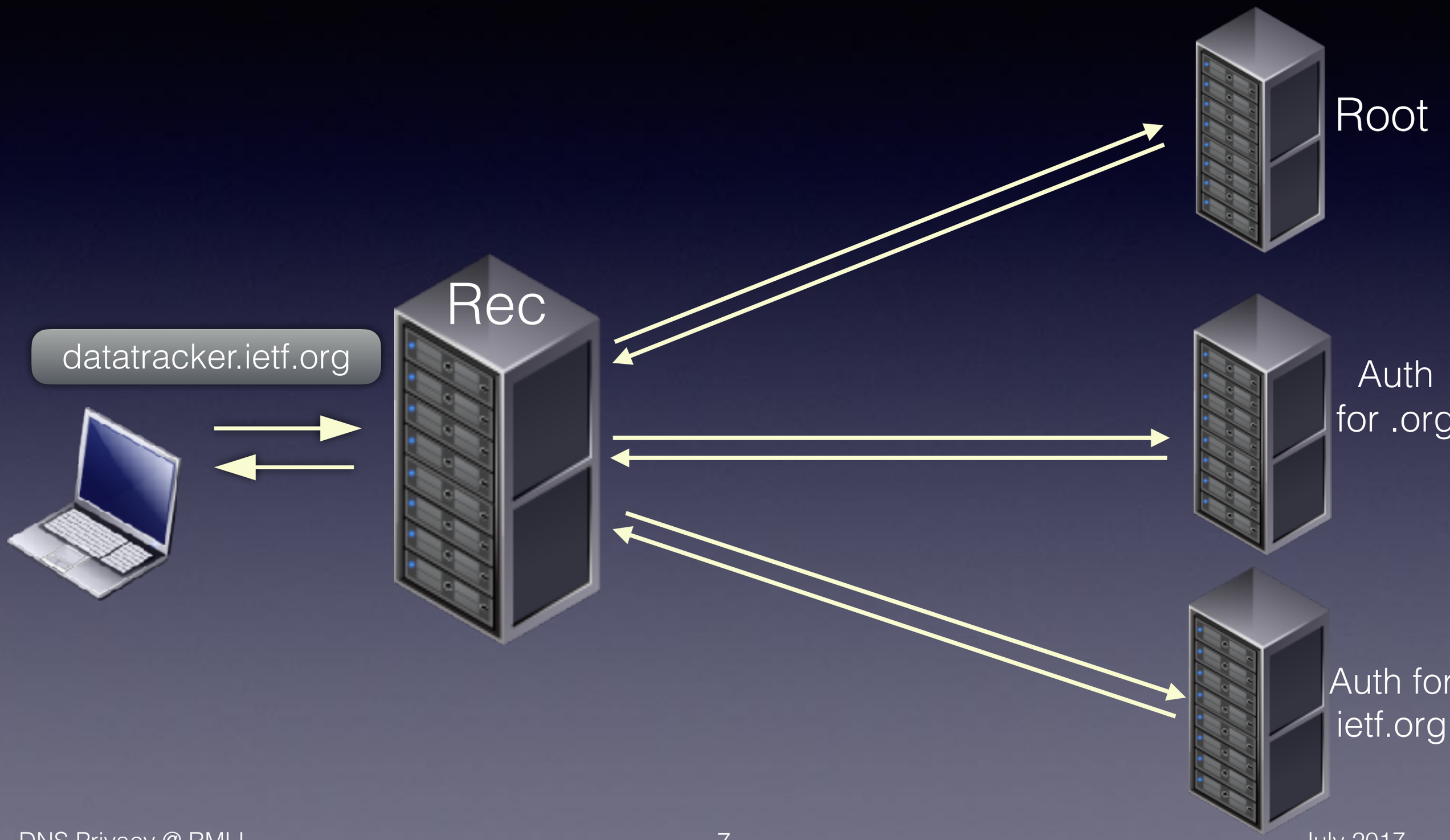

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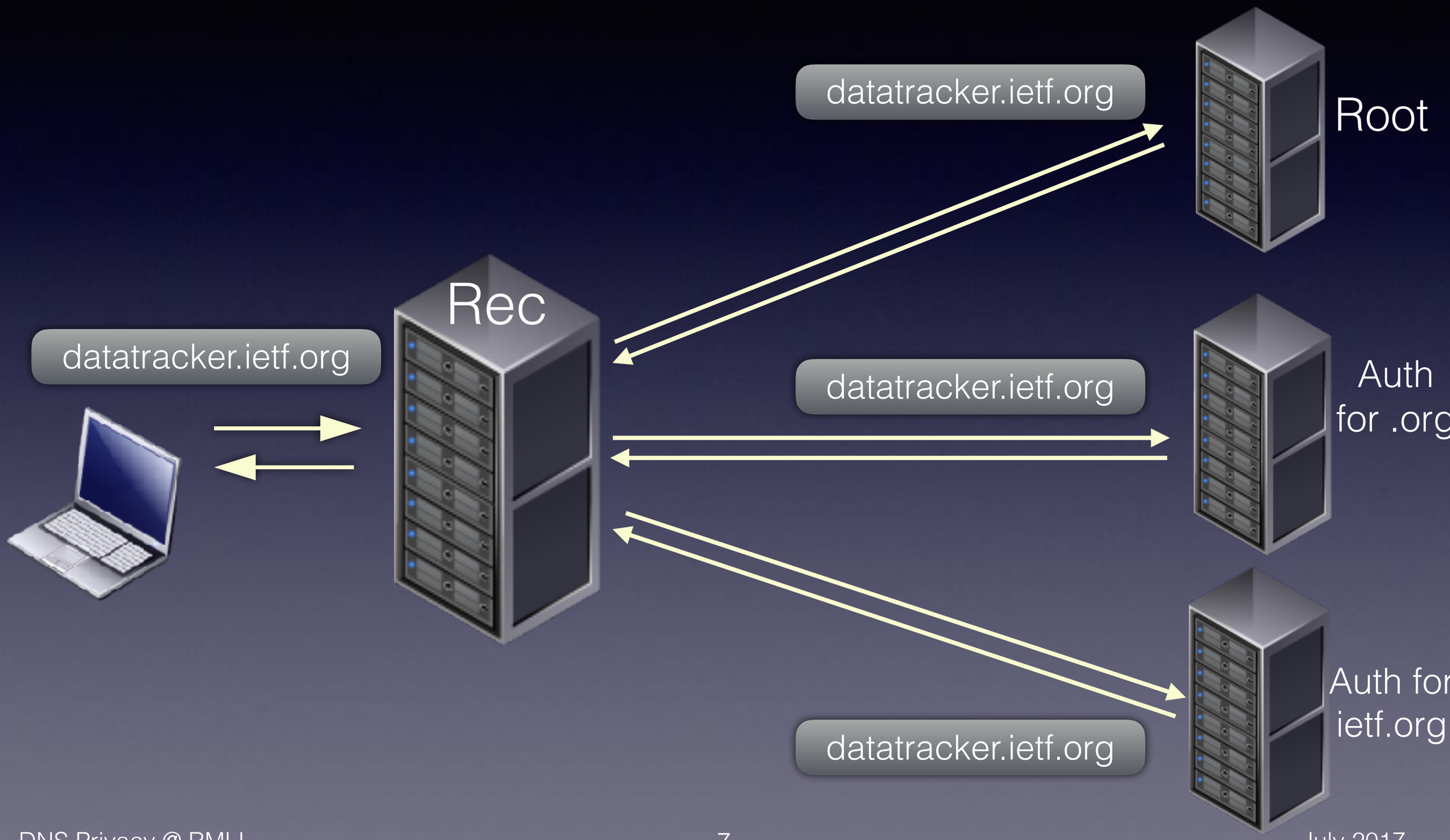

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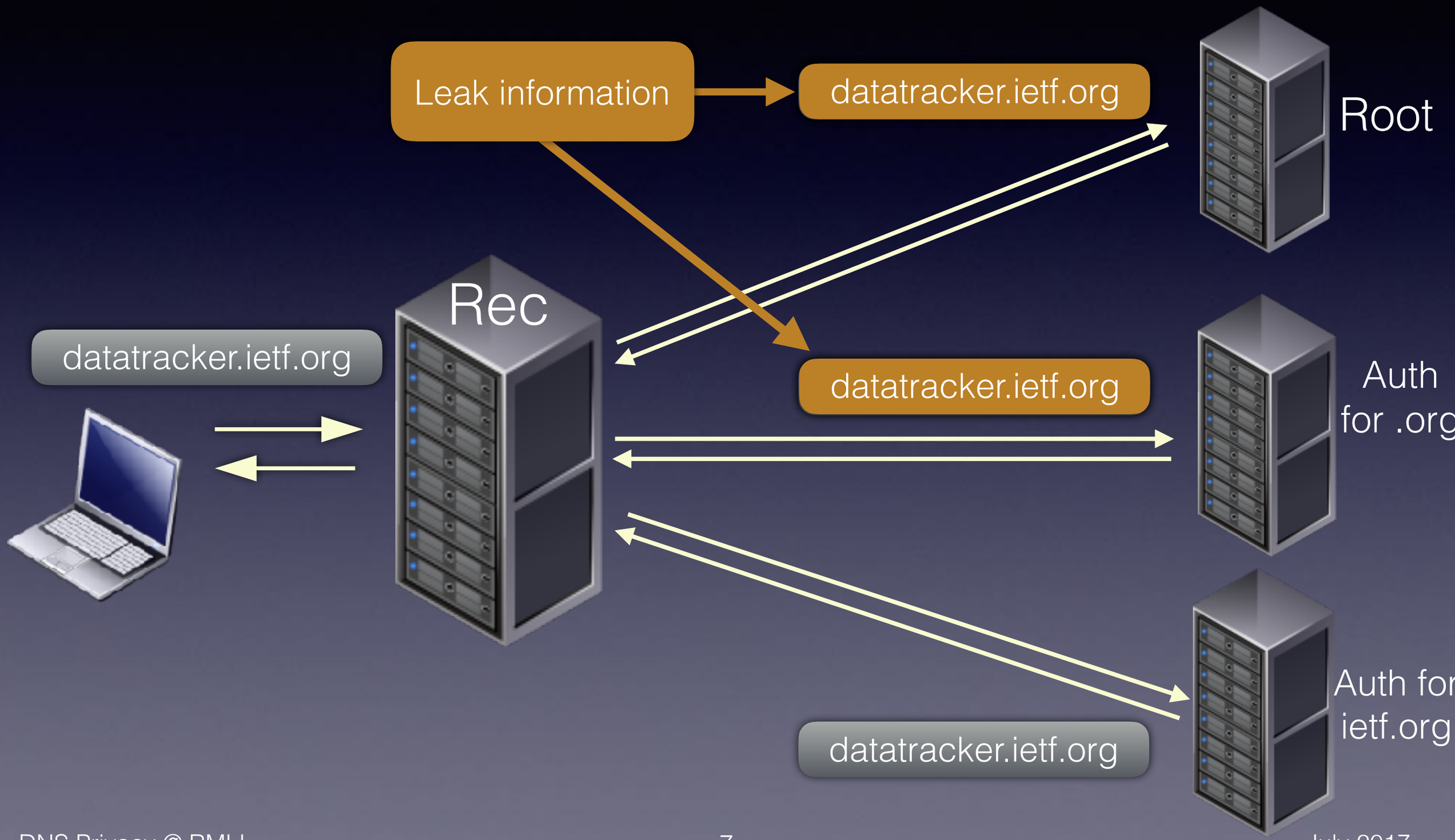

EDNS0 problem

- **RFC6891** (2013): Extension Mechanisms for DNS (EDNS0)

Intended to enhance DNS protocol capabilities

- But…. mechanism enabled addition of **end-user data into** DNS queries (non-standard options)

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ISP justification: Parental Filtering (per user)

CDN justification: Faster content (geo location)

DNS Disclosure Example 2

Parental Filtering

ietf.org ?
[00:00:53:00:53:00]

Stub

CPE

Rec

Auth

[User src address]
MAC address or id
in DNS query

DNS Disclosure Example 2

Parental Filtering

CDN Geo-location

ietf.org ?
[00:00:53:00:53:00]

? ietf.org ?
[192.168.1]

Stub

Rec

Auth

CPE

[User src address]
MAC address or id
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Client Subnet (RFC7871)
contains source subnet
in DNS query

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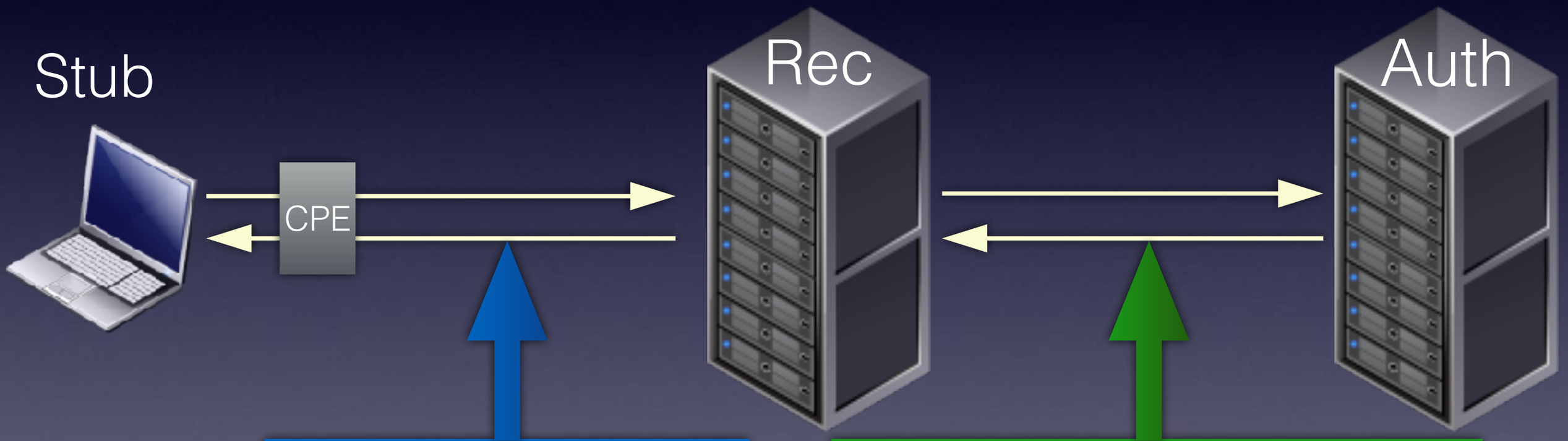

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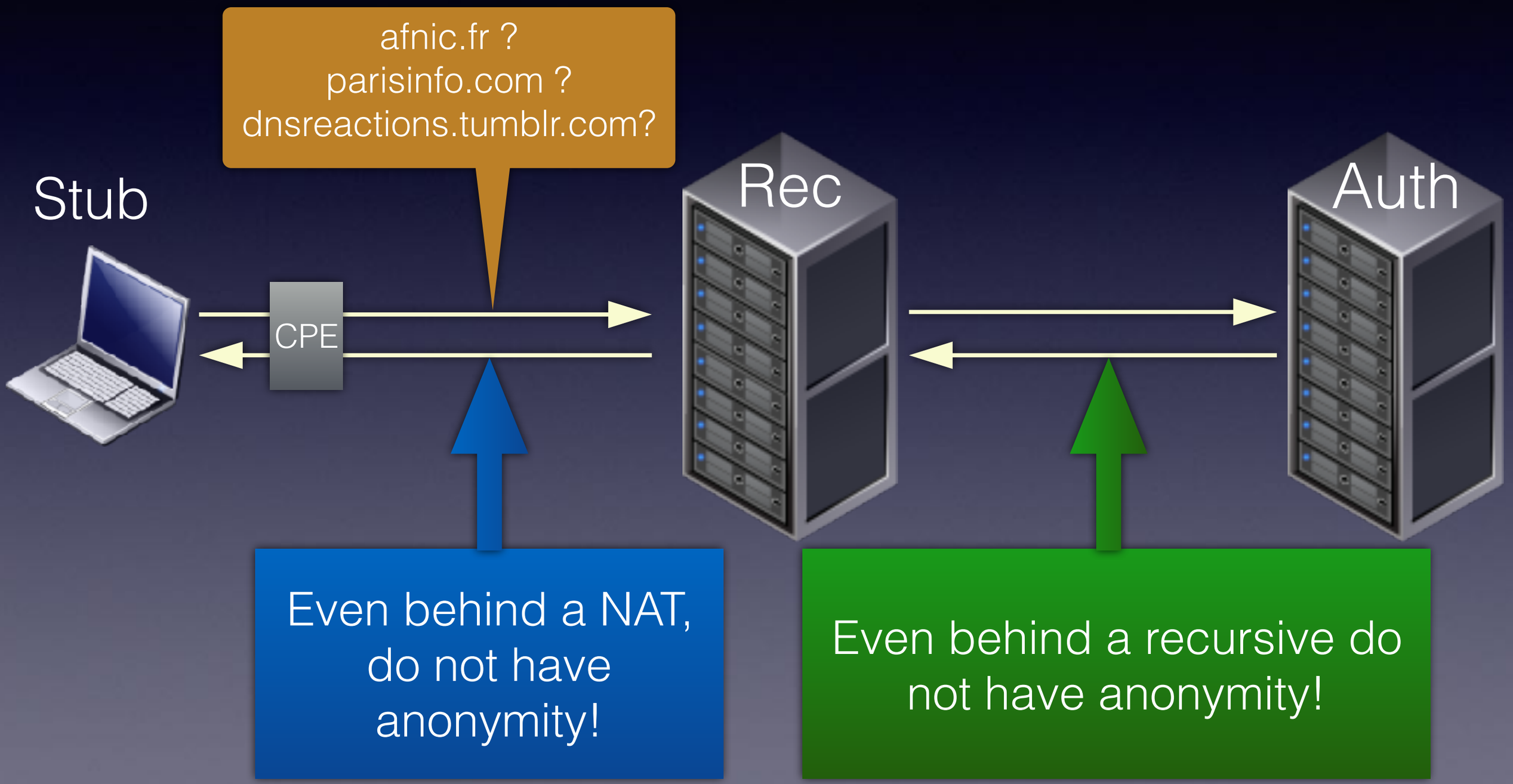

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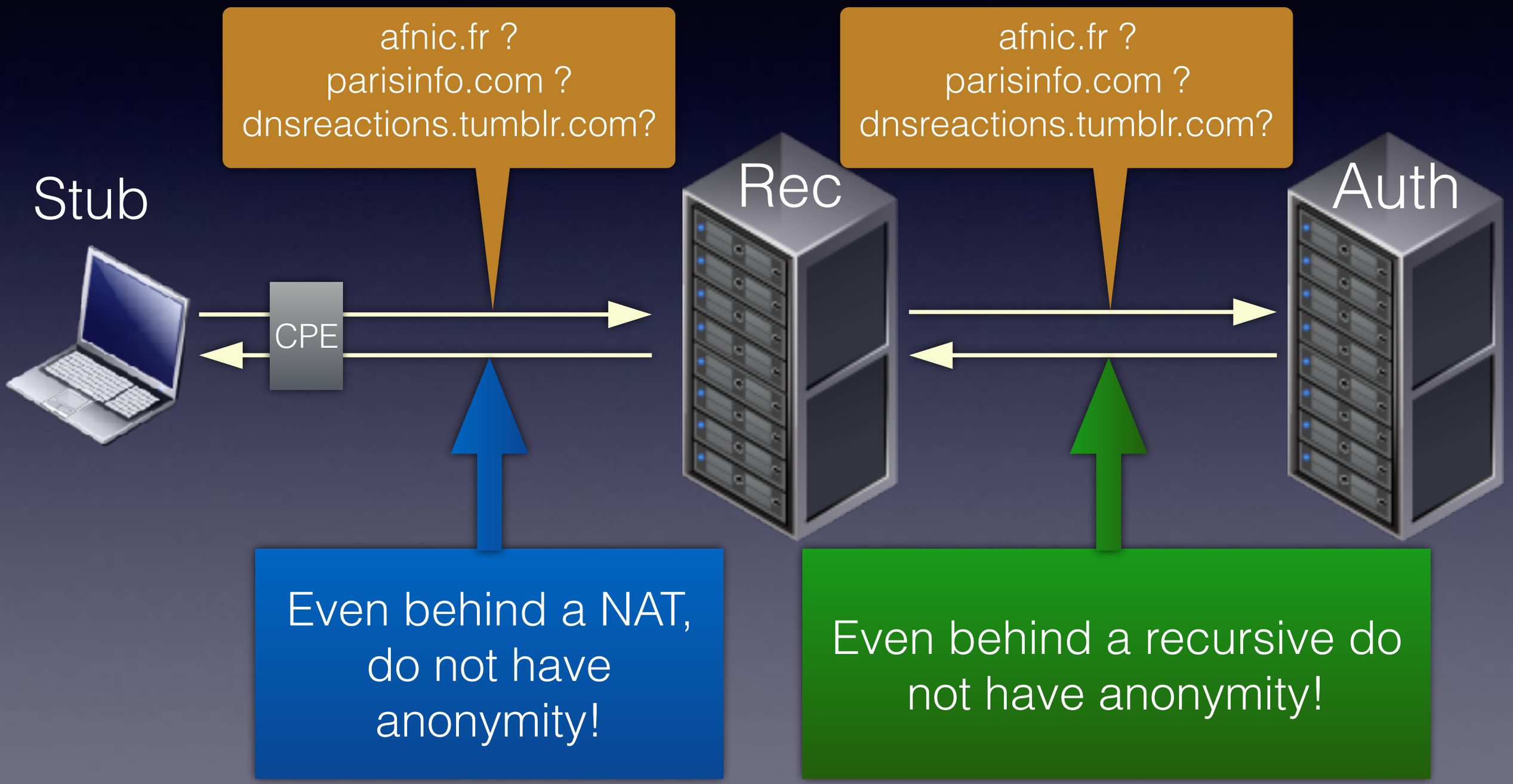

DNS: It’s not just for names

- MX records (email domain)
- SRV records (services)
- OPENPGPKEY (email addresses)
- …this is only going to increase….

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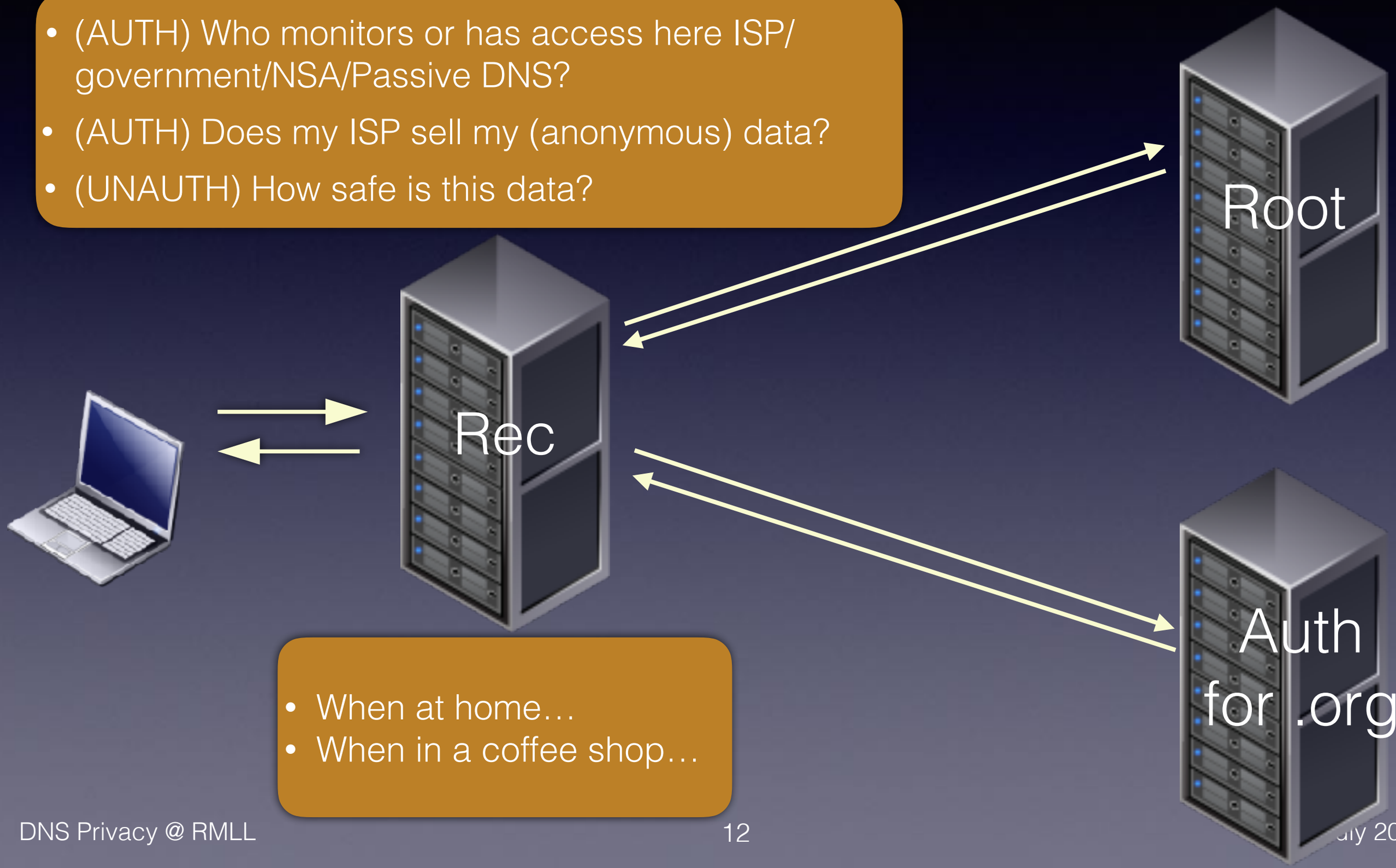
DNS Disclosure Example 3

- (AUTH) Who monitors or has access here ISP/ government/NSA/Passive DNS?
- (AUTH) Does my ISP sell my (anonymous) data?
- (UNAUTH) How safe is this data?



- When at home…
- When in a coffee shop…

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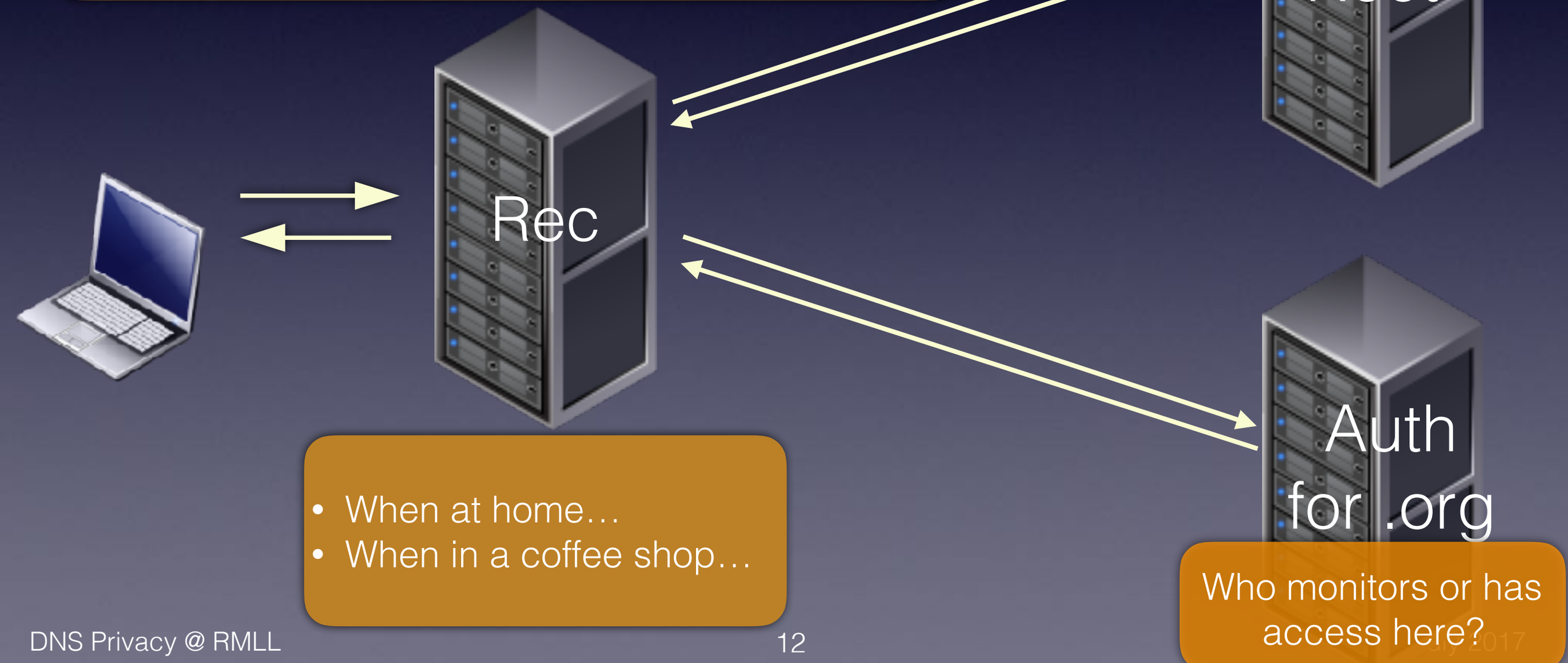

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Who monitors or has access here?

DNS - leakage

- Basic problem is leakage of meta data
  - Allows fingerprinting and re-identification of individuals
  - Even without user meta data traffic analysis is possible based just on timings and cache snooping
  - Operators see (and log) your DNS queries

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DNS Risk Matrix

	In-Flight		At Rest	
Risk	**Stub => Rec**	**Rec => Auth**	**At Recursive**	**At Authoritative**
Passive Monitoring	●	●		
Active Monitoring	●	●		
Other Disclosure Risks e.g. Data breaches			●	●

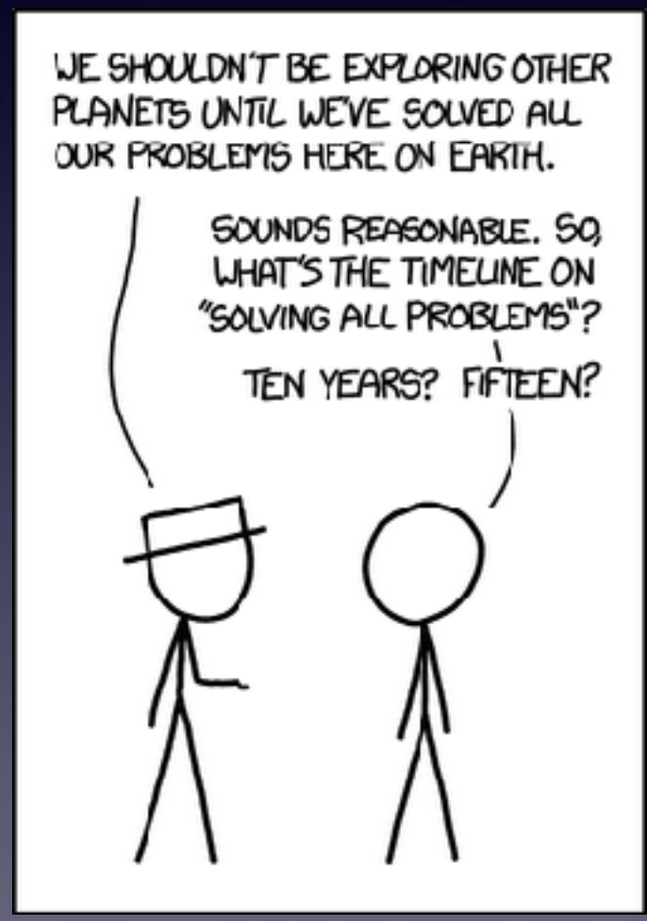
DPRIVE WG

et al.

IETF DPRIVE WG

- DPRIVE WG create in 2014

Charter: Primary Focus is Privacy for Stub to recursive



- **Why not tackle whole problem?**
  - Don't boil the ocean, stepwise solution
  - Stub to Rec reveals most information
  - Rec to Auth is a particularly hard problem

Problem statement: RFC 7626

DNS Privacy Considerations:
Expert coverage of risks throughout DNS ecosystem

- **Rebuts “alleged public nature of DNS data”**
  - The **data** may be public, but a DNS ‘**transaction**’ is not/should not be.

“A typical example from outside the DNS world is: the web site of Alcoholics Anonymous is public; the fact that you visit it should not be.”

Stub/Rec Encryption Options

	Pros	Cons
STARTTLS	• Port 53 • Known technique • Incrementation deployment	• Downgrade attack on negotiation • Port 53 - middleboxes blocking? • Latency from negotiation
TLS (new port)	• New DNS port (no interference with port 53) • Existing implementations	• New port assignment • Scalability?
DTLS (new port)	• UDP based • Not as widely used/ deployed	• Truncation of DNS messages (just like UDP) ➡️Fallback to TLS or clear text ❌Can't be standalone solution

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Encrypted DNS ‘TODO’ list

1. Get a new port
2. DNS-over-TCP/TLS: Address issues in standards and implementations
3. Tackle authentication of DNS servers (bootstrap problem)
4. What about traffic analysis of encrypted traffic - msg size & timing still tell a lot!

Encrypted DNS ‘TODO’ list

1. Get a new port

Oct 2015 - port **853**

2. DNS-over-TCP/TLS: Address issues in standards and implementations
3. Tackle authentication of DNS servers (bootstrap problem)
4. What about traffic analysis of encrypted traffic - msg size & timing still tell a lot!

2. Fix DNS-over-TCP/TLS

Goal	How?
Optimise set up & resumption	**RFC7413**: TFO Fast Open **RFC5077**: TLS session resumption **TLS 1.3** (0-RTT)
Amortise cost of TCP/TLS setup	**RFC7766** (bis of RFC5966) - March 2016: Client pipelining (not one-shot!), Server concurrent processing, Out-of-order responses **RFC7828:** Persistent connections (Keepalive)
Servers handle many connections robustly	**Learn from HTTP world!**

3. Authentication in DNS-over-(D)TLS

- Internet-Draft: Usage Profiles
  - Strict
  - Opportunistic
- Authentication:
  - Name or SPKI pin (requires config)
  - DANE (I-D: TLS DNSSEC Chain Extension)

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3. Authentication in DNS-over-(D)TLS

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  - Opportunistic → 1. Encrypt & Authenticate then 2. Encrypt then 3. Clear text
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DPRIVE Solution Documents (stub to recursive)

Document	Date	Topic
RFC7858	May 2016	DNS-over-TLS
RFC7830	May 2016	4. EDNS0 Padding Option
RFC8094	Feb 2017	DNS-over-DTLS
draft-ietf-dprive-dtls-and-tls-profiles	IESG LC	Authentication for DNS-over-(D)TLS

*Category: Experimental

Other work….

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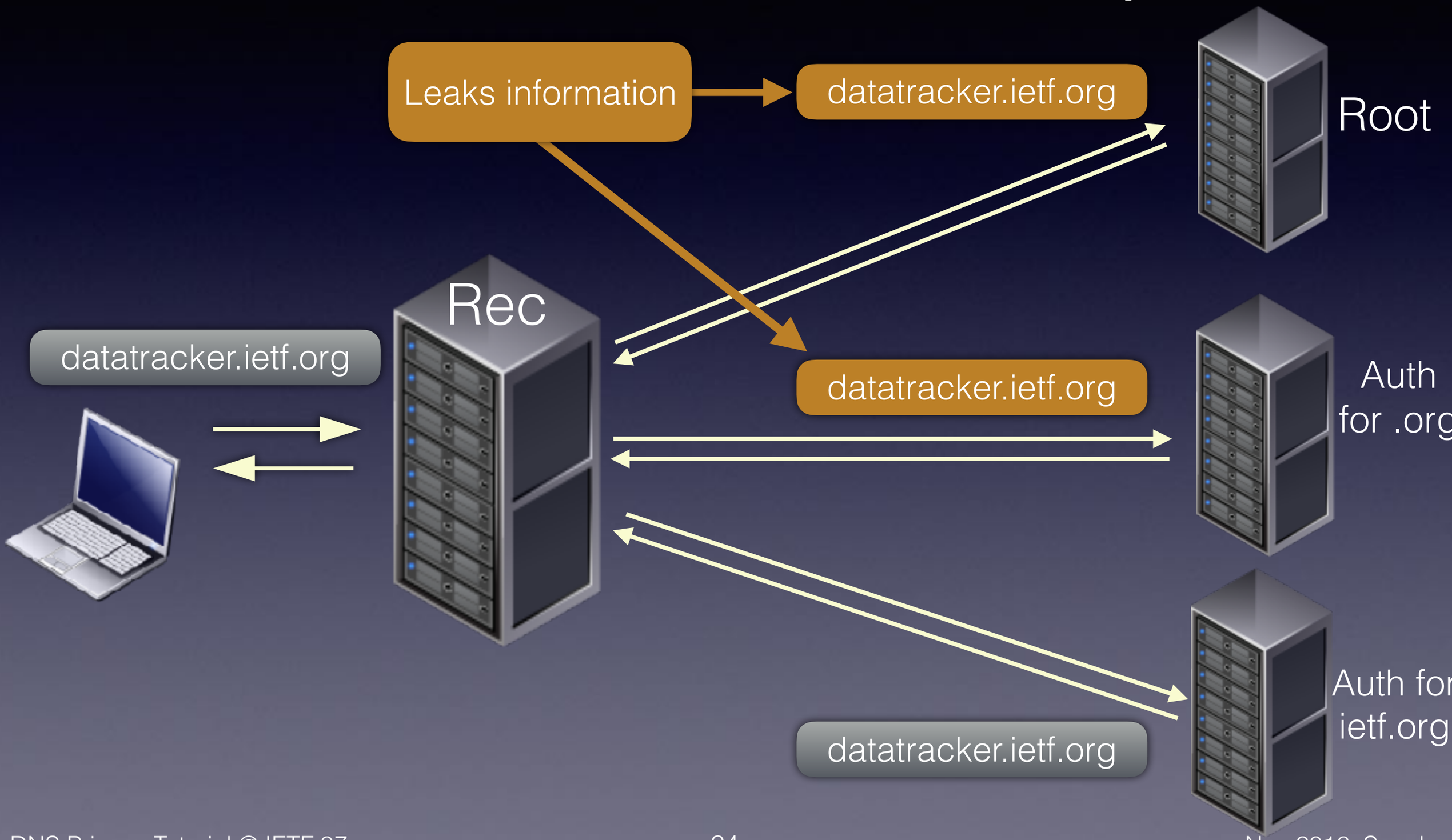
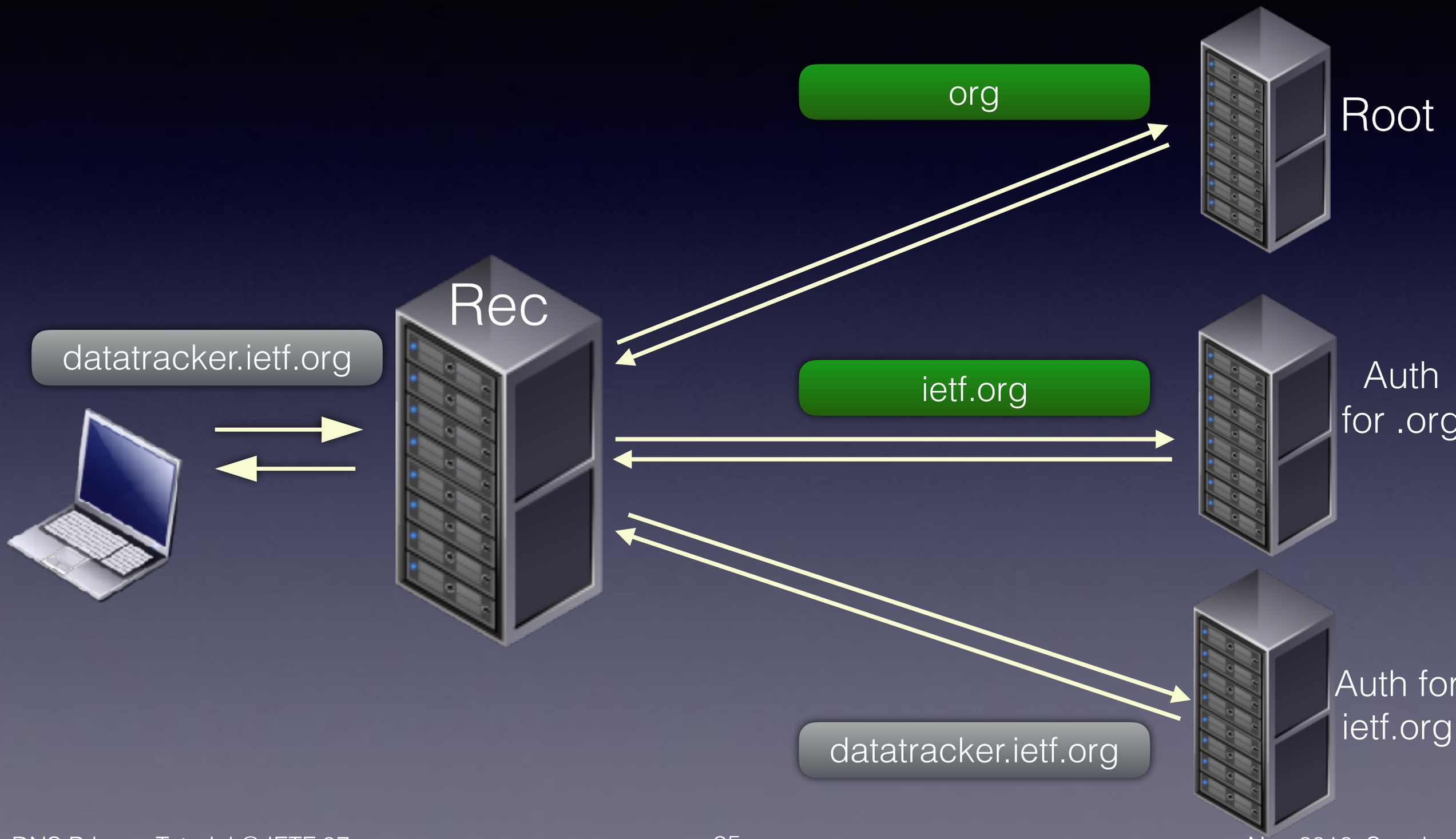


RFC7816: QNAME Minimisation



DNS-over-HTTP(S)

Avoids e.g. port 853 blocking

- Google: DNS-over-HTTPS (non-standard)
- Standards are in flux (many drafts….)
  - DNS wire-format over HTTP (tunnelling)

Implementations exist

  - DNS over HTTPS (query origination)

Mix HTTPS/2 and DNS on one connection

DNS-over-QUIC

- DNS over dedicated QUIC connections
    - QUIC is a developing open source protocol (from Google) that runs over UDP (HTTPS/2-like)
    - **~35% of Google's egress traffic**
      (~7% of Internet traffic)
    - **Reliable**, low latency, performant
    - Source address validation, no MTU limit
    - **Encrypted**

DNS Data handling

- Do you read the small print of your ISPs contract?
- More work/research needed in this area
- **Monitoring** of government policy and practice
- **Transparency** from providers on policy and breaches
- Methods for **de-identification** of user data (e.g. DITL)
- '**PassiveDNS**' data used for research/security

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- **Mon** …tice
- **Tran** …d breaches
- Meth… (e.g. DITL)
- '**PassiveDNS**' data used for research/security

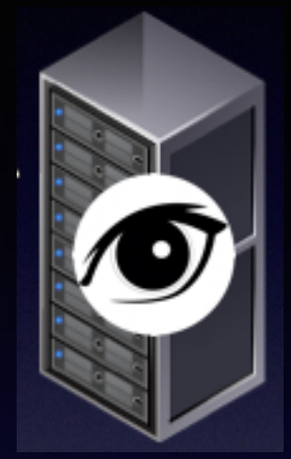
Not always technical solution: Needs more work!

Risk Mitigation Matrix

	In-Flight		At Rest	
Risk	**Stub => Rec**	**Rec => Auth**	**At Recursive**	**At Authoritative**
Passive monitoring	**Encryption (e.g. TLS, HTTPS)**	**QNAME Minimization**		
Active monitoring	**Authentication & Encryption**			
Other Disclosure Risks e.g. Data breaches			**Data Best Practices (Policies) e.g. De-identification**	

DNS Privacy Implementation & Deployment

dnsprivacy.org



- DNS Privacy Project homepage
- **Who?** Sinodun, NLnet Labs, Salesforce,…
  (plus various grants and individual contributions)
- **What?** Point of reference for DNS Privacy services
  - Quick start guides for operators & end users
  - Ongoing work - presentations, IETF, Hackathons
  - Tracking of DNS-over-TLS experimental servers

RECURSIVE

Server Side Solutions

- Recursive (open source) implementations
  - *Unbound, Knot Resolver* support DNS-over-TLS

- Using a pure TLS load balancer (with e.g. *BIND*)
  - *NGINX, HAProxy, stunnel, docker image*
  - Requested support in *dnsdist*

- Let's Encrypt certificate management automation

RECURSIVE

Experimental!

DNS-over-TLS Servers

(all using Open Source)

Hosted by	Notes
NLnet Labs	Unbound
Surfnet (Sinodun)	BIND + HAProxy BIND + nginx
UncensoredDNS	Unbound
dns.cmrg.net	Knot Resolver

10 at last count - find details at: DNS Test Servers

RECURSIVE

Experimental!

Server monitoring

Project dnsprivacy-monitoring

* Green indicates success

* Red indicates failed test (this might result from non DNS related issues such server being off line, blocking from the probe location, etc.) Note that the 'Strict mode' tests could fail for a number of reasons including incorrect credentials, self-signed certificates for name only authentication, incompatible TLS version or Cipher suites, etc. The console log of the test may give more information.

* Grey indicates test not run (e.g. due to lack of available transport or the lack of the SPKI pin)

Authentication information is taken from https://dnsprivacy.org/wiki/display/DP/DNS+Privacy+Test+Servers
These tests use Stephane Bortzmeyer's nagios plugin - see https://github.com/bortzmeyer/monitor-dns-over-tls

Configuration Matrix		Responds over TLS	Strict mode - Name only	Strict mode - SPKI only	Certificate expiry > 0 days	Certificate expiry > 14 days	QNAME minimisation used
getdnsapi.net	v6	✓	✓	✓	✓	✓	✓
	v4	✓	✓	✓	✓	✓	✓
dnsovertls.sinodun.com	v6	✓	✓	✓	✓	✓	!
	v4	✓	✓	✓	✓	✓	!
dnsovertls1.sinodun.com	v6	✓	✓	✓	✓	✓	!
	v4	✓	✓	✓	✓	✓	!
dns.cmrg.net	v6	✓	✓	✓	✓	✓	✓
	v4	✓	✓	✓	✓	✓	!
tls-dns-u.odvr.dns-oarc.net	v6	✓	!	!	✓	✓	!
	v4	✓	!	!	✓	✓	!
dns-resolver.yeti.eu.org	v6	✓	✓	✓	✓	✓	✓
	v4	●	●	●	●	●	●
yeti-rr.datev.net	v6	✓	✓	✓	✓	✓	✓
	v4	●	●	●	●	●	●
unicast.censurfridns.dk	v6	✓	✓	●	✓	✓	!
	v4	✓	✓	●	✓	✓	!
dns-tls.openbsd.se	v6	●	●	●	●	●	●
	v4	✓	✓	✓	✓	✓	!

Stubby

- A open source privacy enabling stub resolver: User Guide

- Available in getdns (1.1.1 release) - open source
  - Run as daemon handling requests
  - Configure OS DNS resolution to point at *localhost*
  - DNS queries then proxied over TLS
  - Comes with config for experimental servers

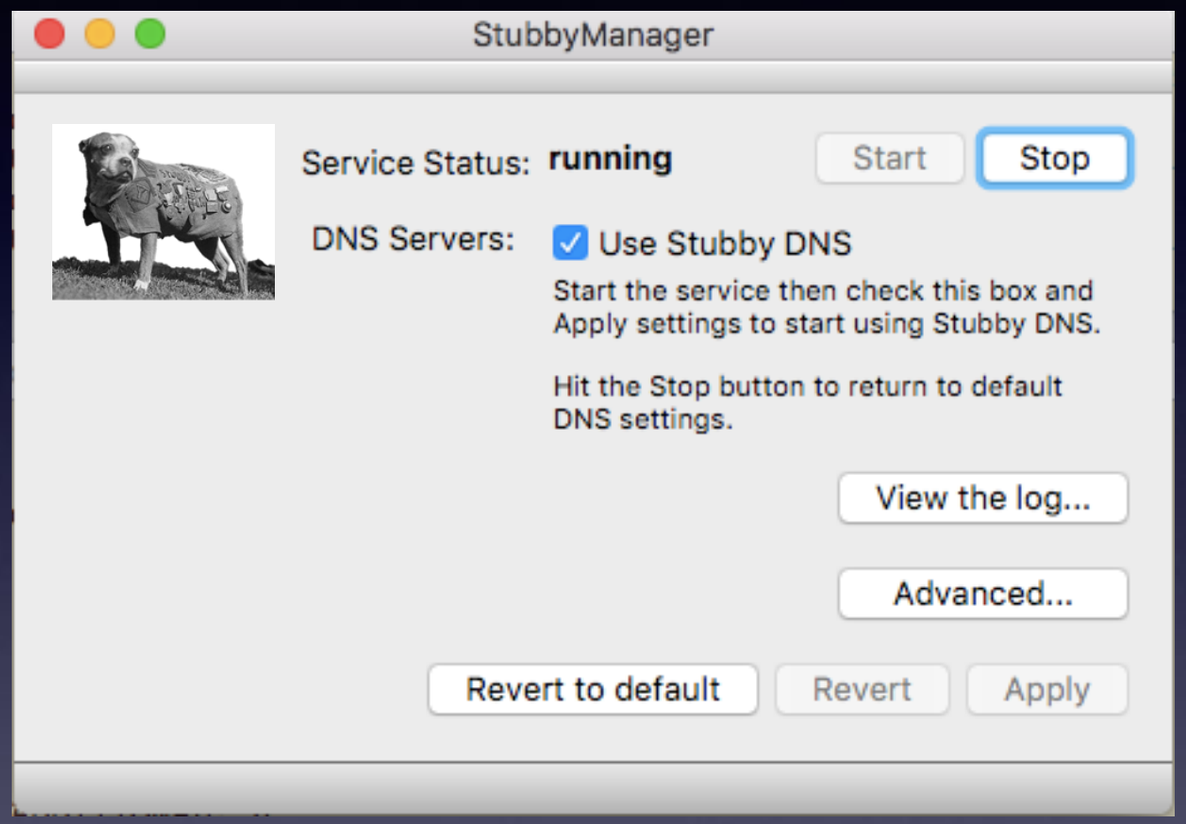
Stubby Status

- Command line tool - for ‘advanced’ users
  - Supports name and SPKI pinset authentication
  - Strict and Opportunistic profiles
- Homebrew formula, docker image, packages and macOS UI on the way….. (DNSSEC)

CLIENTS

Prototype!
HELP WANTED

SubbyUI preview



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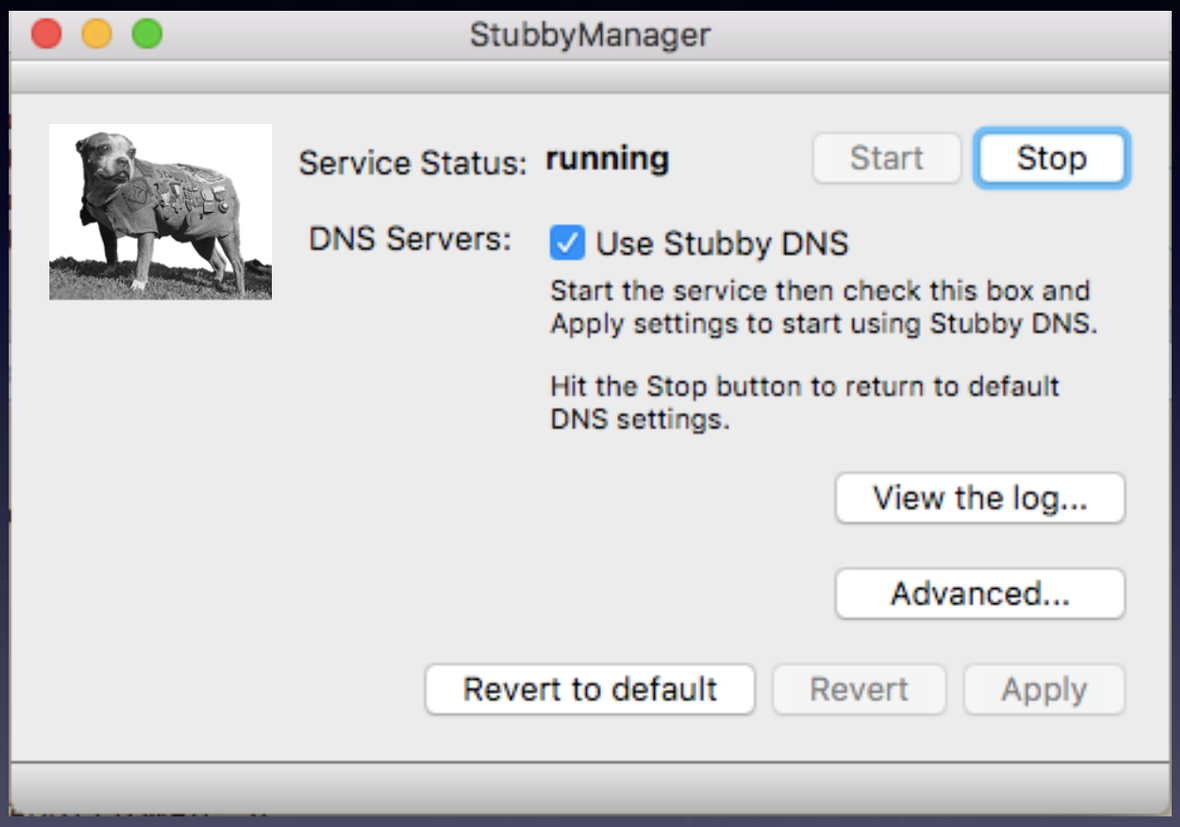

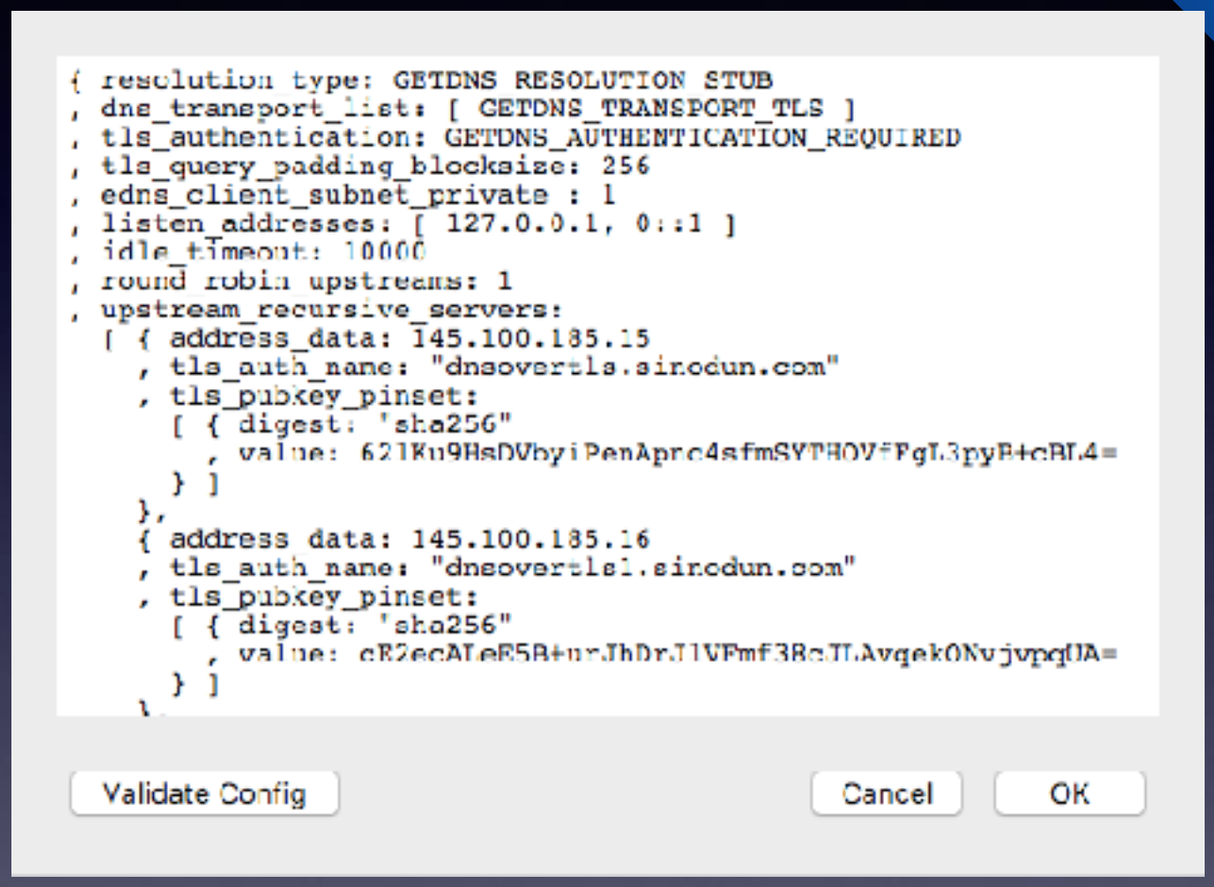

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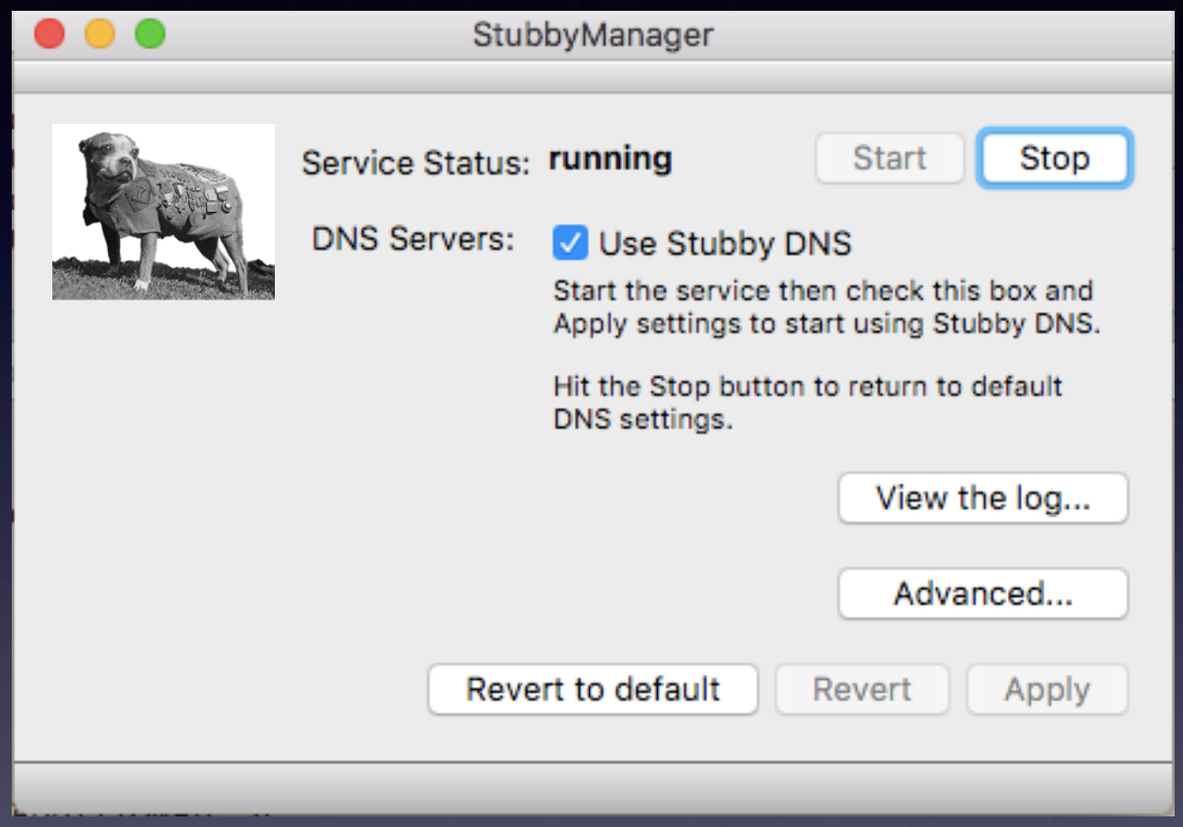

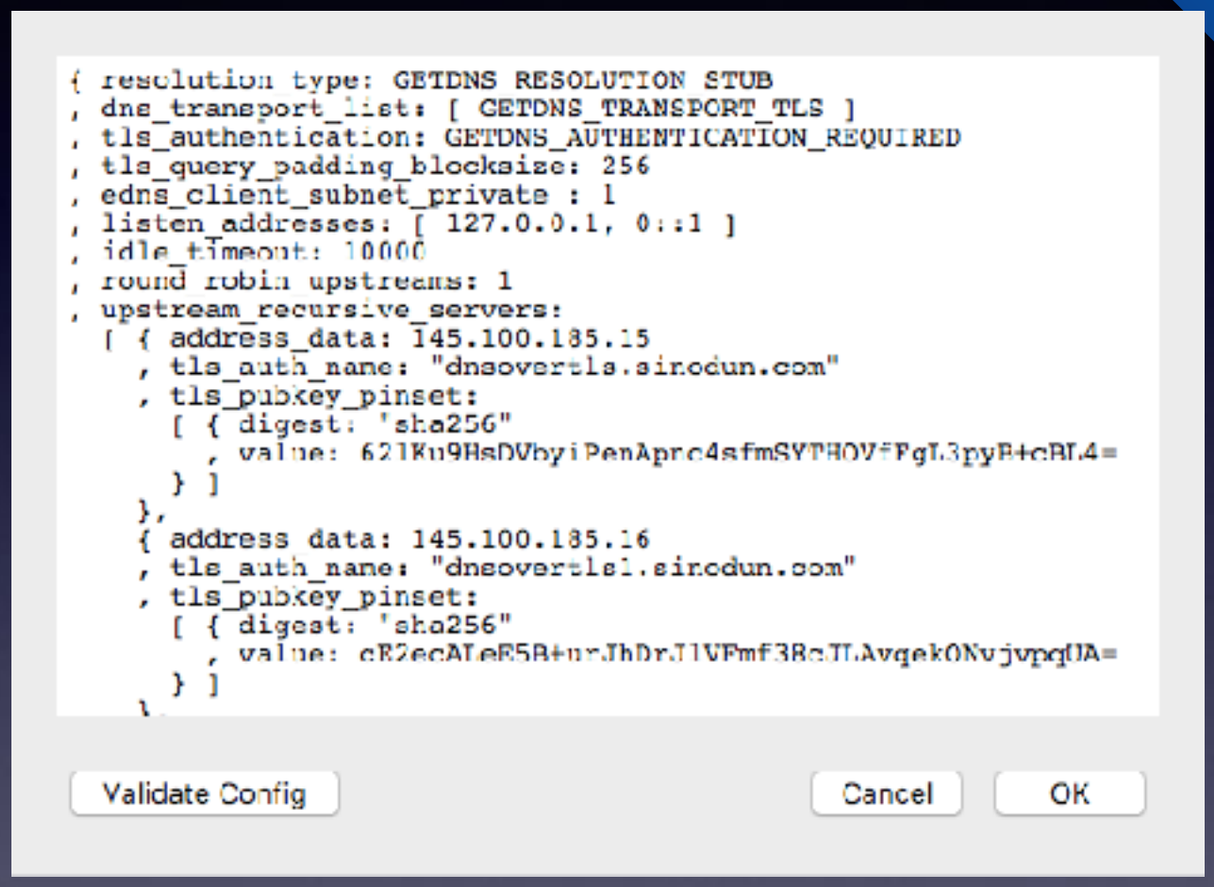

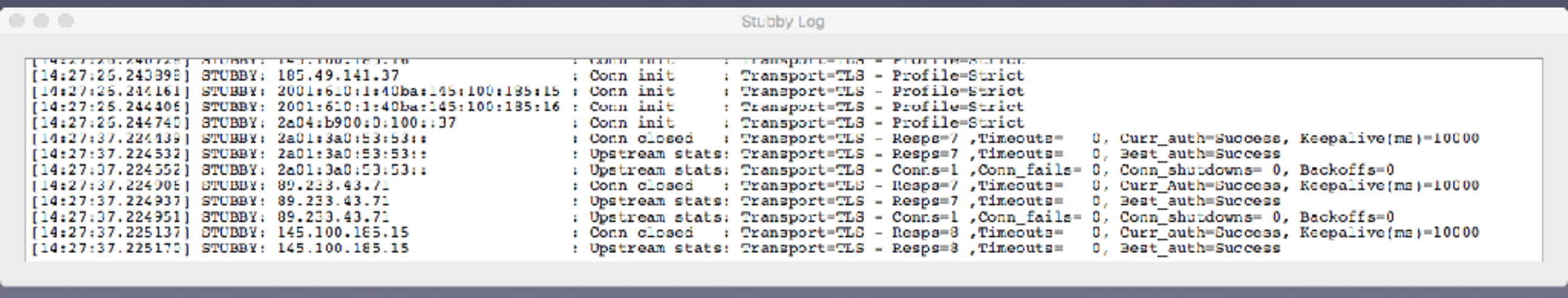

Stubby Usability

- DNS Privacy is a new paradigm for end users
- End users are a new paradigm for DNS people!

- '**Usable Security**': Good GUIs aren't enough - users still struggle with the basics if they don't understand what they are doing (HTTPS, PGP, DNSSEC)

- DNS Privacy uptake critically dependant on clients being usable + successful

Key challenges

1. Awareness!
2. Clients: OS integration of (more) client solutions
3. Usable client solutions for non-technical users
4. Increased deployment (anycast deployments)
5. Operator transparency in DNS data handling
6. Recursive to Authoritative….

Summary

- DNS Privacy is a real problem and more relevant than ever
- Active work on the large solution space
- Can use DNS Privacy today using Stubby & current experimental recursive servers
- More DNS Privacy services on the way…

Thank you!

Any Questions?

dnsprivacy.org