Encrypted DNS

(2020 Update)

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Agenda

- DNS-Privacy
- DoH/DoT/DoQ
- The current status
- Oblivious DoH and Adaptive DNS resolver discovery

About me?

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RIPE/IETF

Privacy in DNS?

- in recent years, the IETF has expanded the DNS protocol with privacy features
  - DNS-over-TLS (Transport-Encryption between DNS client and DNS resolver)
  - DNS-over-HTTPS (Transport-Encryption between DNS client and DNS resolver)
  - QNAME Minimization (less metadata in DNS)
  - EDNS-Padding (*hiding* of DNS data in encrypted connections)

The need for more DNS privacy

- a study presented at IETF 105 during the Applied Networking Research Workshop in July 2019 found that
  - 8.5 % of networks (AS) intercept DNS queries (27.9% in China)
  - (today) most queries are answered un-altered
- but the situation might change, intercept server might change DNS answers

encrypted transport for DNS

encrypted DNS terminology

- Terminology
  - Do53 = **DNS-over-Port53** - classic DNS (UDP/TCP port 53)
  - DoT = **DNS-over-TLS** - TLS as the transport for DNS
  - DoH = **DNS-over-HTTPS** - HTTPS as the transport for DNS
  - DoQ = **DNS-over-QUIC** - QUIC as the transport for DNS
  - DoC = **DNS-over-Cloud** - DNS resolution via cloud services (Google, Q9, Cloudflare …)

DoT - DNS-over-TLS

- RFC 7858 "Specification for DNS over Transport Layer Security (TLS)"
- DNS wireformat over TLS over TCP
- Port 853 (TCP)
- Encryption and Authentication (Internet PKI or via DANE)

DoH - DNS over HTTP(S)

- RFC 8484 *DNS Queries over HTTPS (DoH)* (P. Hoffman, ICANN and P. McManus, Mozilla) https://tools.ietf.org/html/rfc8484
- DNS HTTP-Format over HTTPS over TCP, Port 443 (HTTP/2)
- URL: `https://server/dns-query{?dns}`
- Encryption, Authentication and Cloaking

DoT vs DoH

- differences between DoT and DoH
  - DoT can be easily blocked, because it is running on an dedicated port (853)
  - DoH is made to look like normal HTTPS traffic, selective blocking of DoH is difficult
  - DoH seems to be easier to implement, because of existing HTTPS library functions in programming languages
  - DoH enables developers to do DNS name resolution on an application level, which some people think is bad

Controlling DoH - the Canary Domain

Controlling DoH - the Canary Domain

- Mozilla has implemented a check for a *Canary Domain* in Firefox
- Domain Name `use-application-dns.net.`
  - if the domain-name **can** be resolved via DNS53 -> unmanaged DNS, DoH can be auto-enabled
  - if the domain-name **cannot** be resolved (= is blocked) -> managed DNS, DoH will not be auto-enabled (but users can manually enable DoH)
- the IETF is discussing similar signalling functions: "Signaling resolver's filtering policies" (draft-mglt-add-signaling-filtering-policies)

other checks done by Firefox before enabling DoH

- Resolve canary domains of certain known DNS providers to detect content filtering
- Resolve the *safe-search* variants of `google.com` and `youtube.com` to determine if the network redirects to them
- On Windows and macOS, detect parental controls enabled in the operating system
- additional checks performed for private *enterprise* networks are:
  - Is the Firefox `security.enterprise_roots.enabled` preference set to true?
  - Is any enterprise policy configured?

Current DoT/DoH client status

Firefox Browser

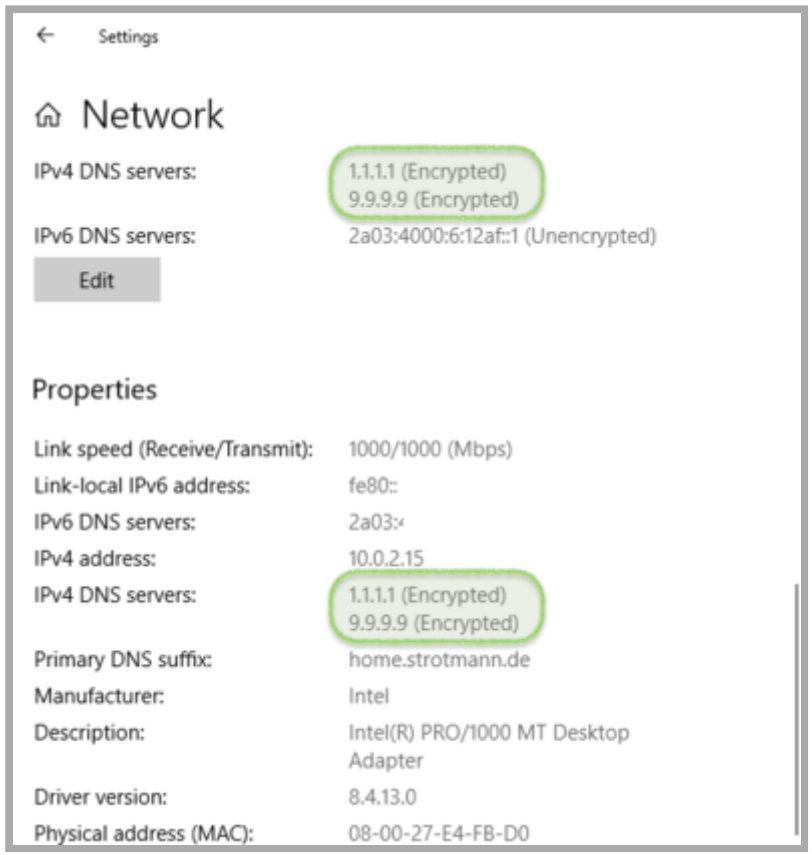
- Firefox Trusted Recursive/Remote Resolver (TRR) Program
  - Cloudflare (default) or NextDNS
  - Comcast XFinity (coming)
  - automatic rollout started in February 2020

Chrome(ium) Browser

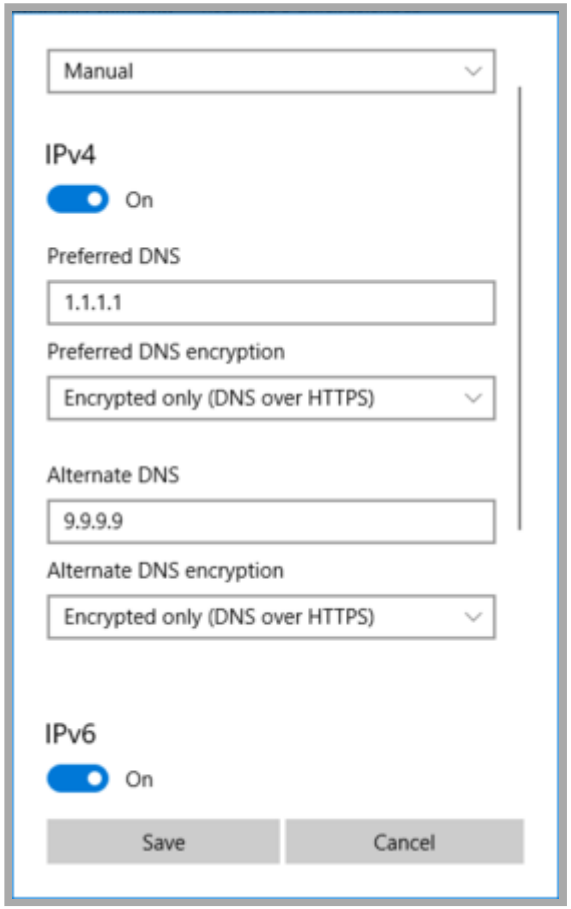
- DoH is implemented and can be enabled by the user
  - Google Chrome
  - Opera
  - Vivaldi
  - Brave
  - Microsoft Edge
  - Bromite
- DoH "auto upgrade" for the configured DNS resolvers (manual configured or DHCP/RA supplied)
- Google is experimenting with adaptive DoH-Resolver-Discovery via DNS

Microsoft Windows 10 (1/2)

- support in latest "Insider" builds of Windows 10



Microsoft Windows 10 (2/2)



Linux

- DoT support in `systemd-resolved` for some time
- opportunistic mode only (automatic fallback to DNS53)
- no server authentication (MITM possible)
- global or "per interface" setting
- not enabled by default

OpenBSD

- DoT support in `unwind`
- not enabled by default
- opportunistic "auto update" mode or manual configured "strict" mode
- server authentication via TLS certificate

Android

- DoT available from Andoid 9 "Pie"
- manual setting
- "auto upgrade" from the configured DNS resolver, or Google DNS as fallback
- auto upgrade to DoH in Chrome for Android Version 85+ (September 2020)

Apple MacOS 11 and iOS/iPadOS 14

- support for DoT and DoH
- global and per App/Application resolver selection possible
- "encrypted DNS" configuration Apps possible, user can choose provider by installing App
- OS can learn "per Domain" DoH/DoT setting via DNS or HTTP (Adaptive DNS-over-HTTPS)
- OS can discover DoH/DoT Server via DHCP/PvD (Provisioning Domains) or queries to `resolver.arpa` via classic DNS53
- Discovery methods in active discussion in the IETF ADD working group

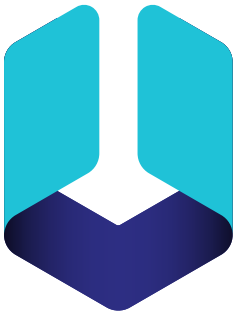
Current DoT/DoH server status

BIND 9

- DoH/DoT support is currently in the BIND 9.17 development branch (**not for production use**)
- BIND 9.18 will contain DoH and DoT support
  - scheduled for early in 2021, will be the ‘2021 stable release’
- ISC has also committed to backporting DoH and DoT to BIND 9.16 (Extended Support Version)

Unbound

- the Unbound DNS resolver does support DoT since 2017 (and had support for DNS-over-SSL via Port 443 before that)
- support for DNS-over-HTTPS (DoH) has been merged into the Unbound source code and is scheduled for Unbound 1.11.1 in October 2020



unbound

other DNS Resolver

- dnsdist is an open source DNS load-balancer that supports DoT and DoH
- some commercial TLS loadbalancer (e.g. A10) support DoH and/or DoT
- NGINX, the popular open source webserver and protocol proxy, does support DoT and DoH
- more DoT/DoH implementations can be found on the presenters encrypted DNS implementations page

Adaptive DNS-over-HTTPS

Adaptive DNS-over-HTTPS

- Goals (directly taken from the Internet Draft):
  - No party other than the client and server can learn or control the names being queried by the client or the answers being returned by the server.
  - Only a designated DNS resolver associated with the deployment that is also hosting content will be able to read both the client IP address and queried names for Privacy-Sensitive Connections.
  - Clients will be able to comply with policies required by VPNs and local networks that are authoritative for private domains

Designated DoH server for domains

- DoH Servers for a domain can be learned
  - from DNSSEC secured HTTPS/SVCB records
  - HTTP(S) `ALT-SVC` header
  - DoH-Server "well-known" URL
  - local provisioning domain (PvD)

HTTPS Record

- eliminates additional roundtrip (DNS or HTTP)
- the HTTPS DNS record provides
  - address information (`ipv4hint`, `ipv6hint`)
  - protocol information (protocol upgrade request -> HTTP/3[QUIC])
  - public keys (encrypted client hello)
  - other data, such as encrypted DNS resolver hint (`dohuri`)

HTTPS Record Example

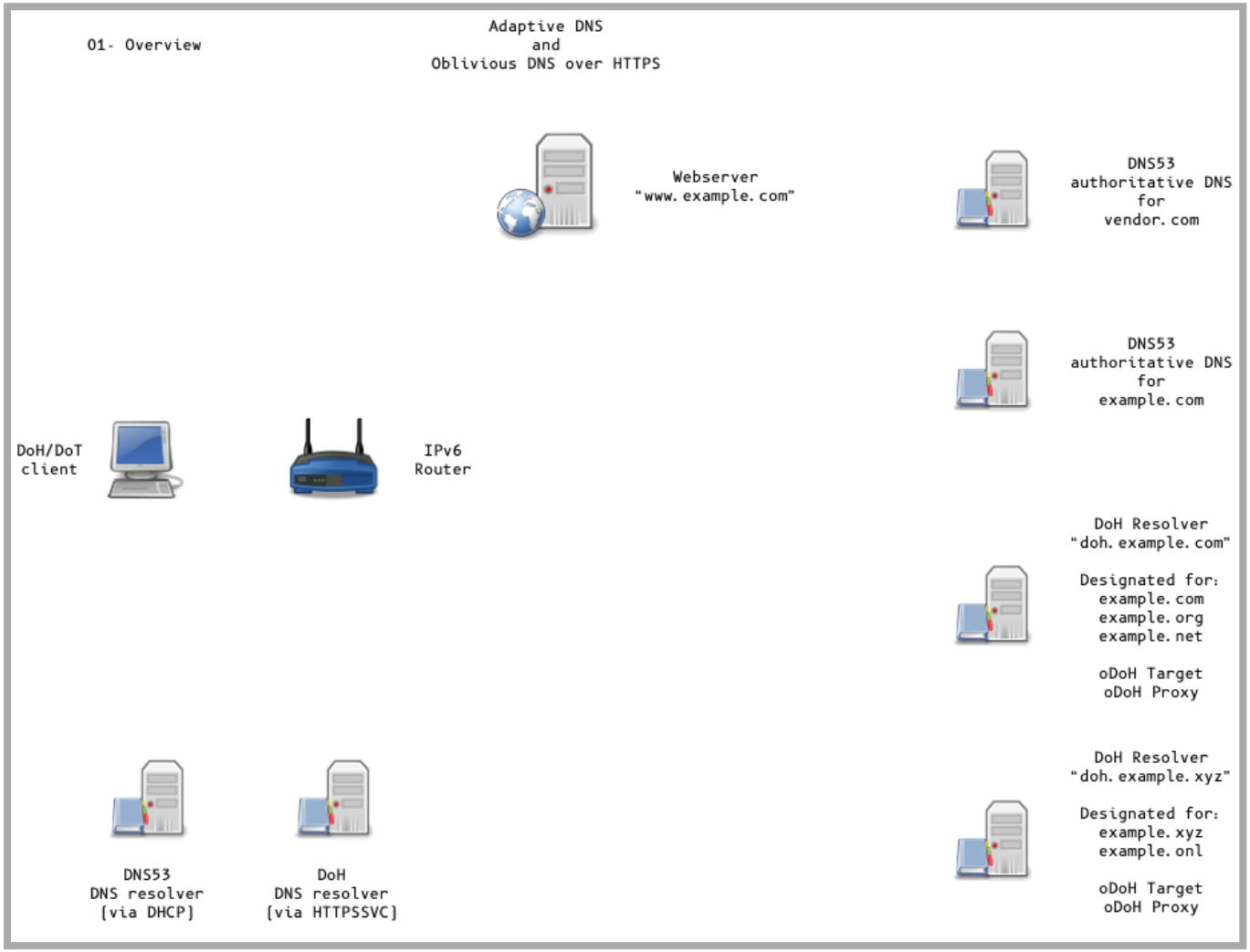
```
example.com.        IN HTTPS 0 svc.example.net.
svc.example.net.    IN HTTPS 2 svc1.example.net. (
                         dohuri=https://doh.example.net/dns-query
                         odohkey="..." )
```

https://www.ietf.org/id/draft-ietf-dnsop-svcb-https-01.txt

Oblivious DoH (oDoH)

- oDoH is an extension to DoH that allows client IP addresses to be disassociated from queries via proxying (pauly-dprive-oblivious-doh)

Adaptive DNS Discovery and oDoH



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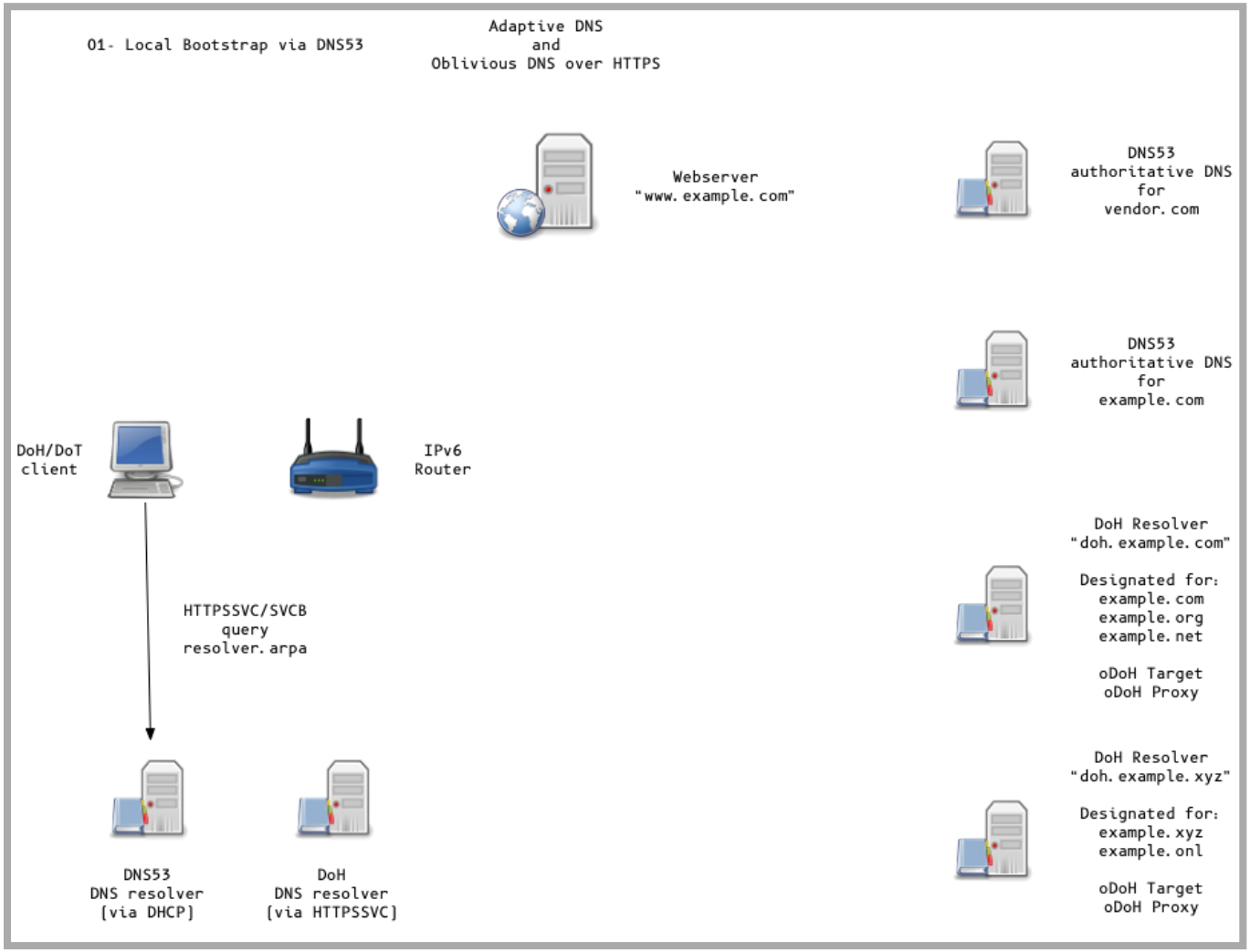

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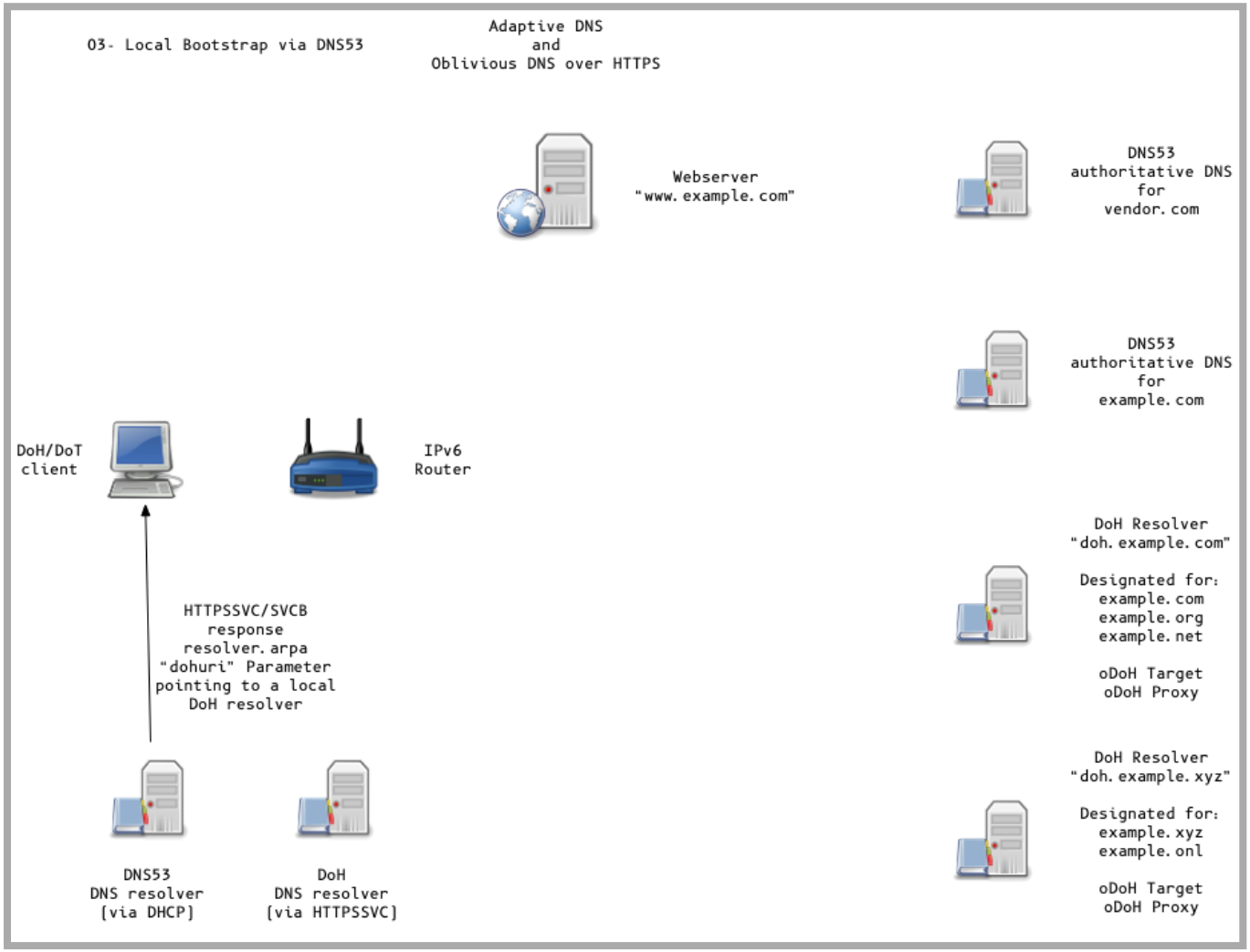

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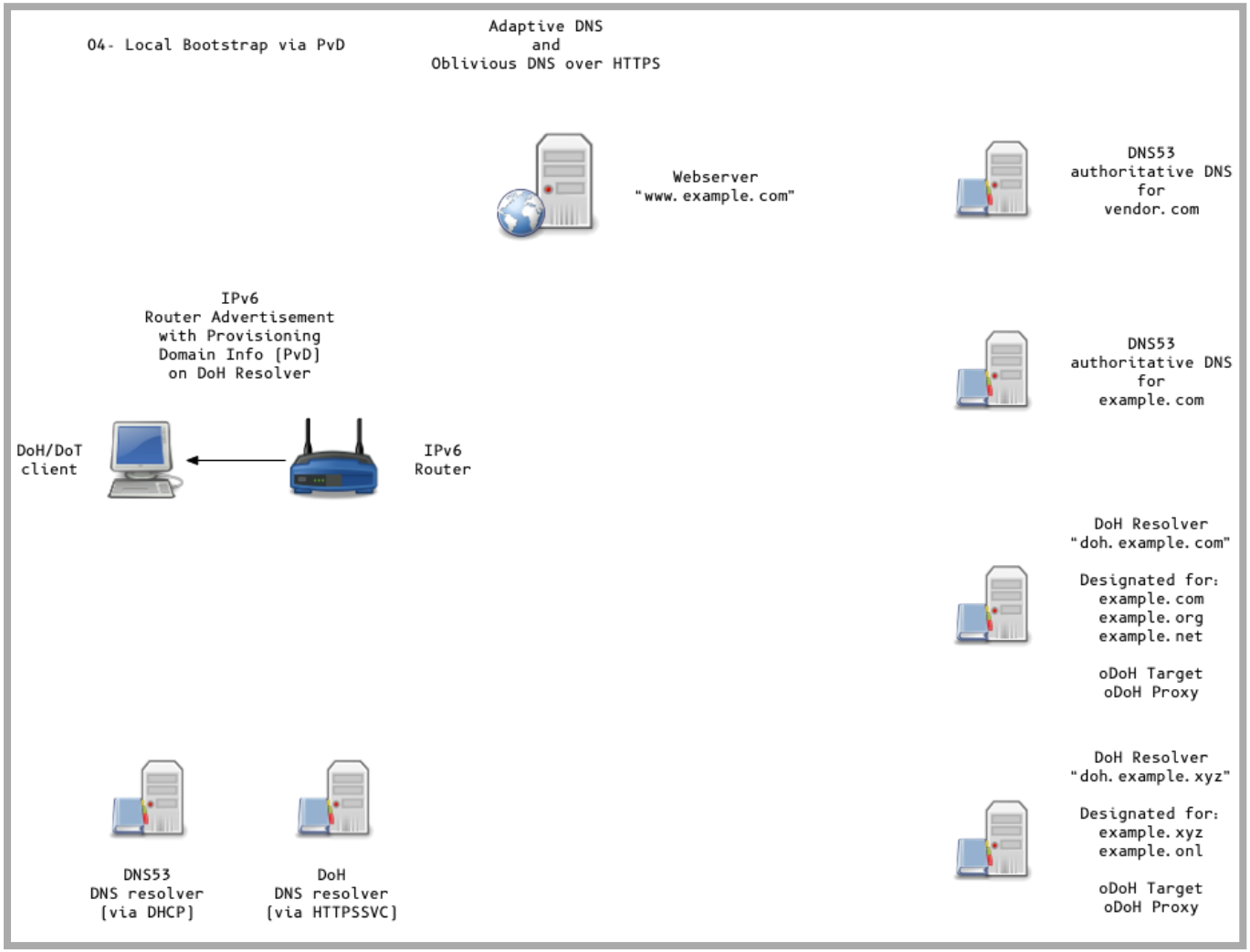

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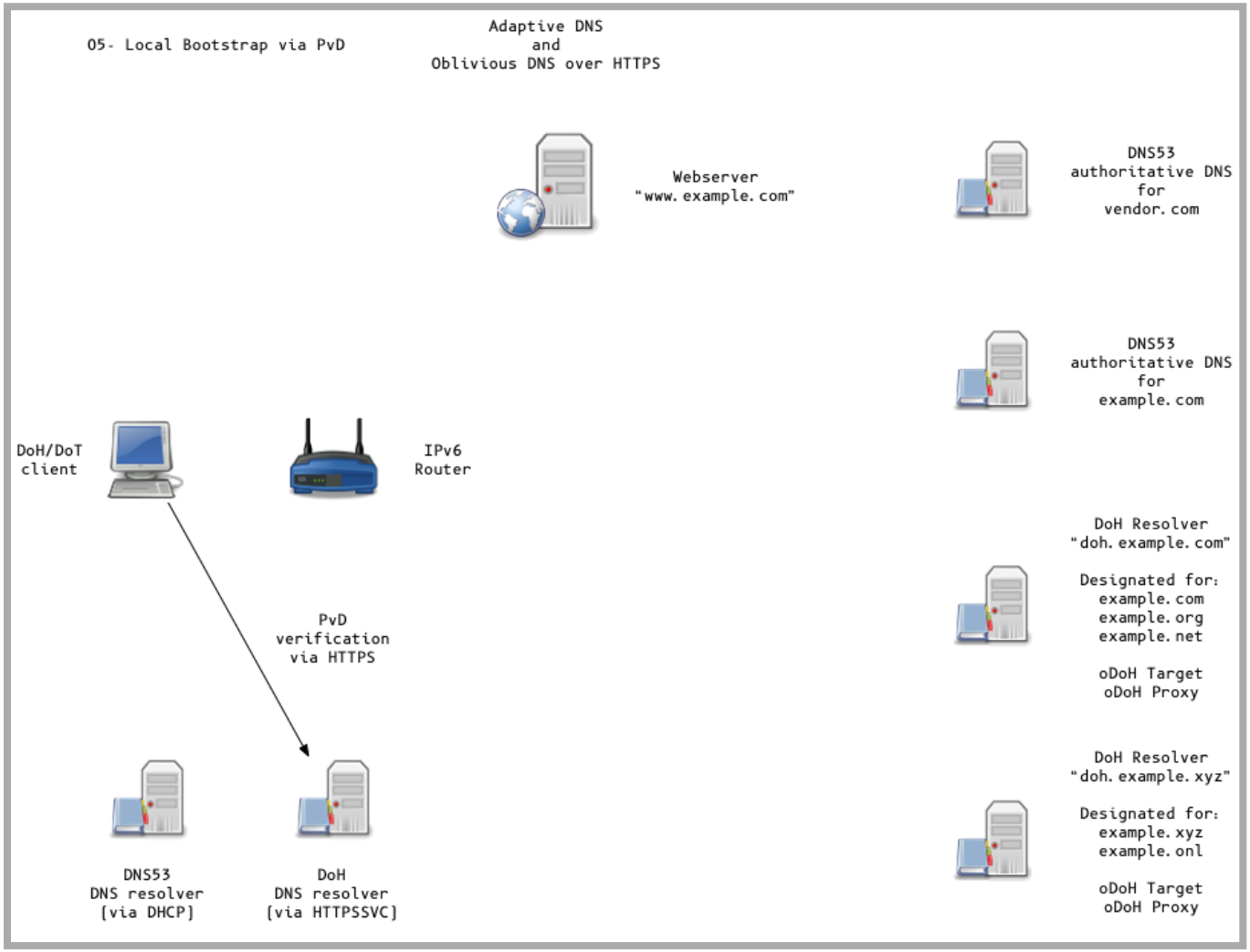

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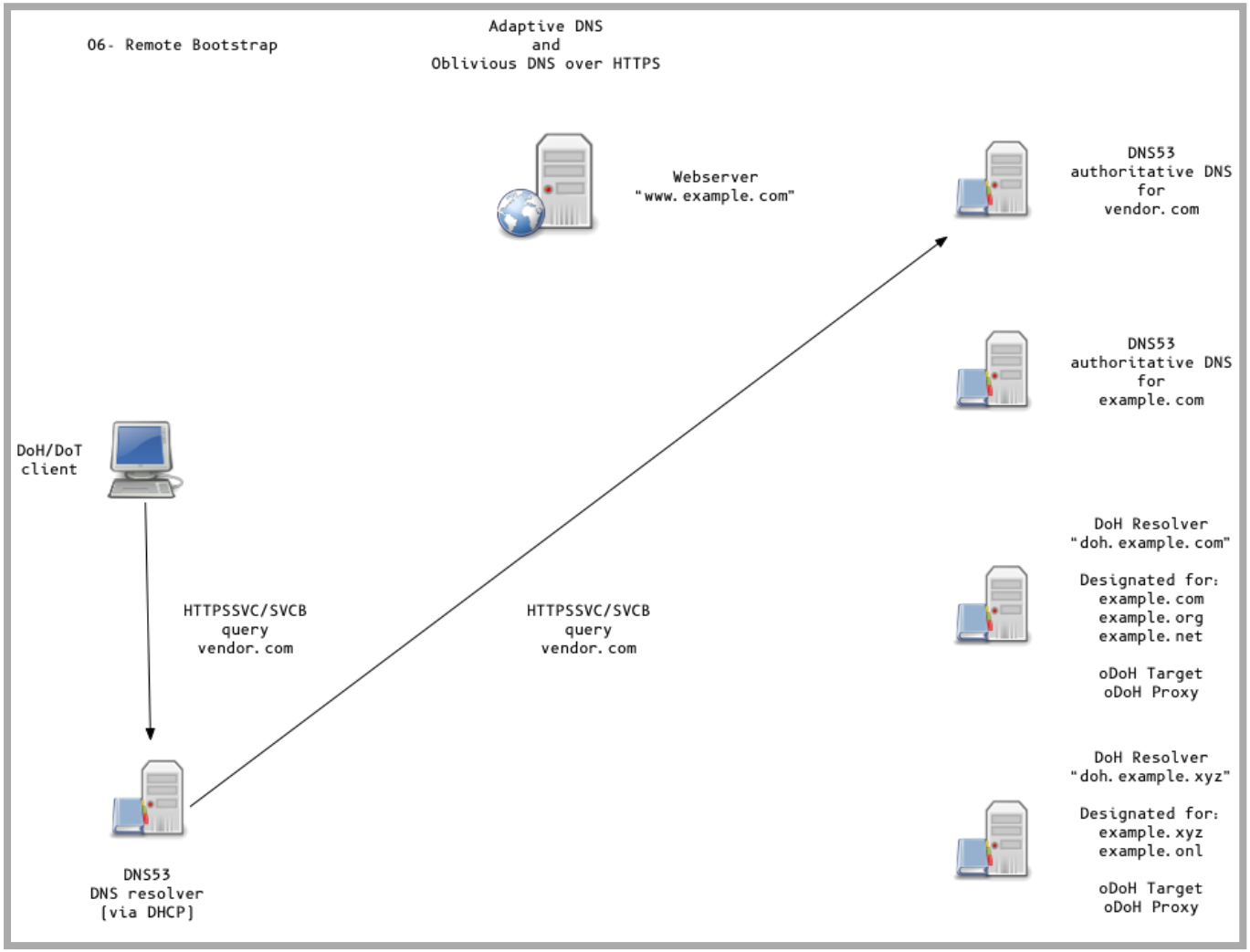

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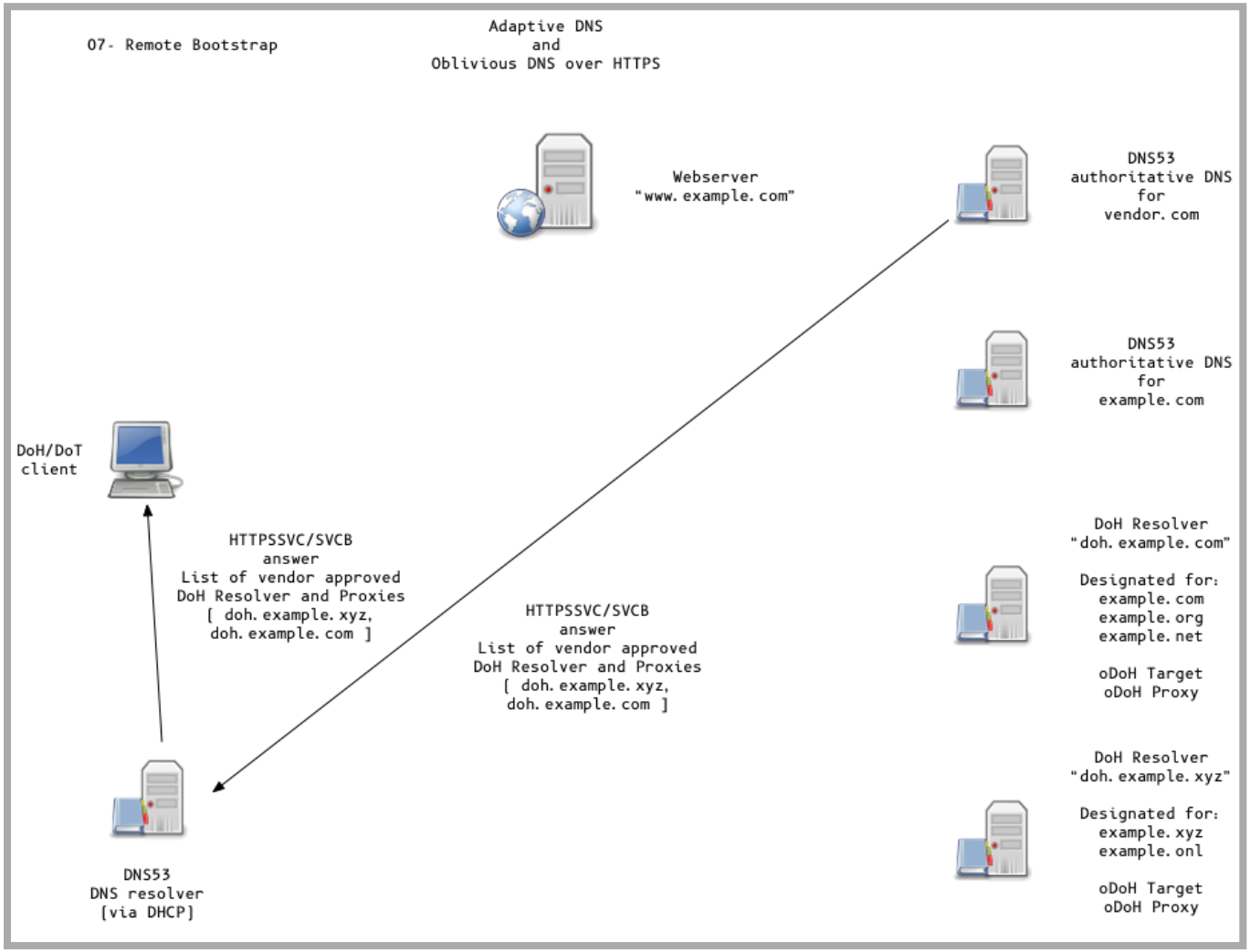

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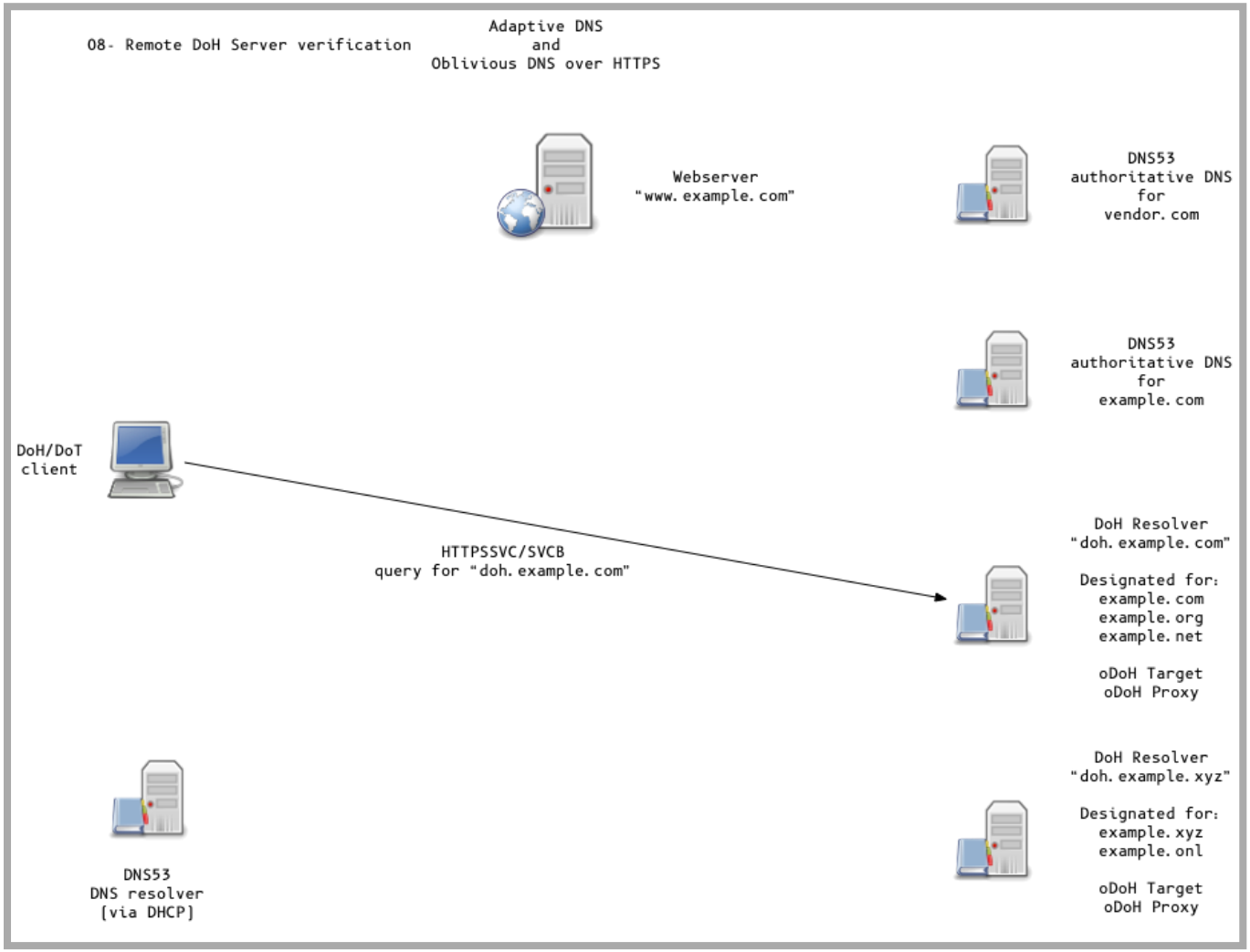

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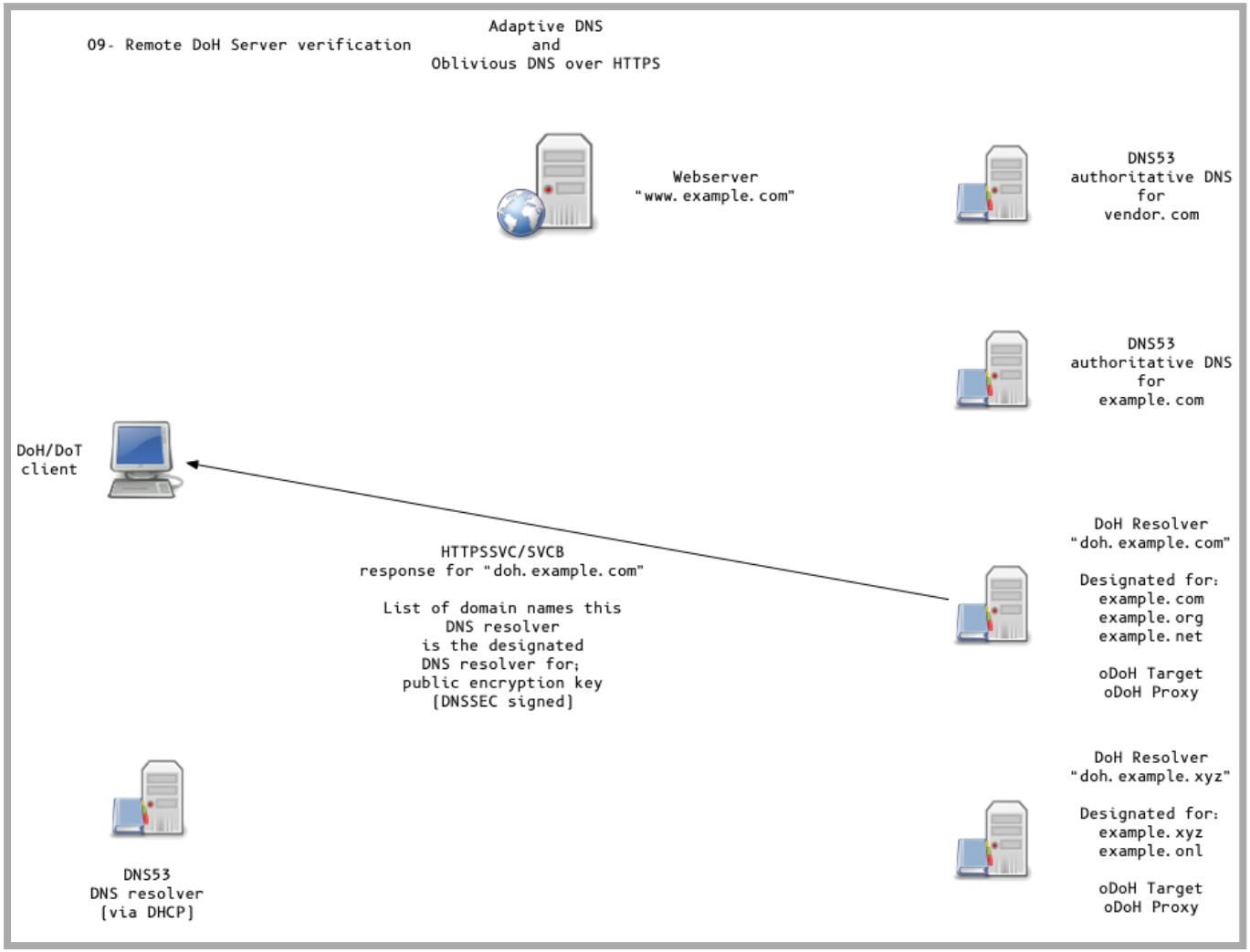

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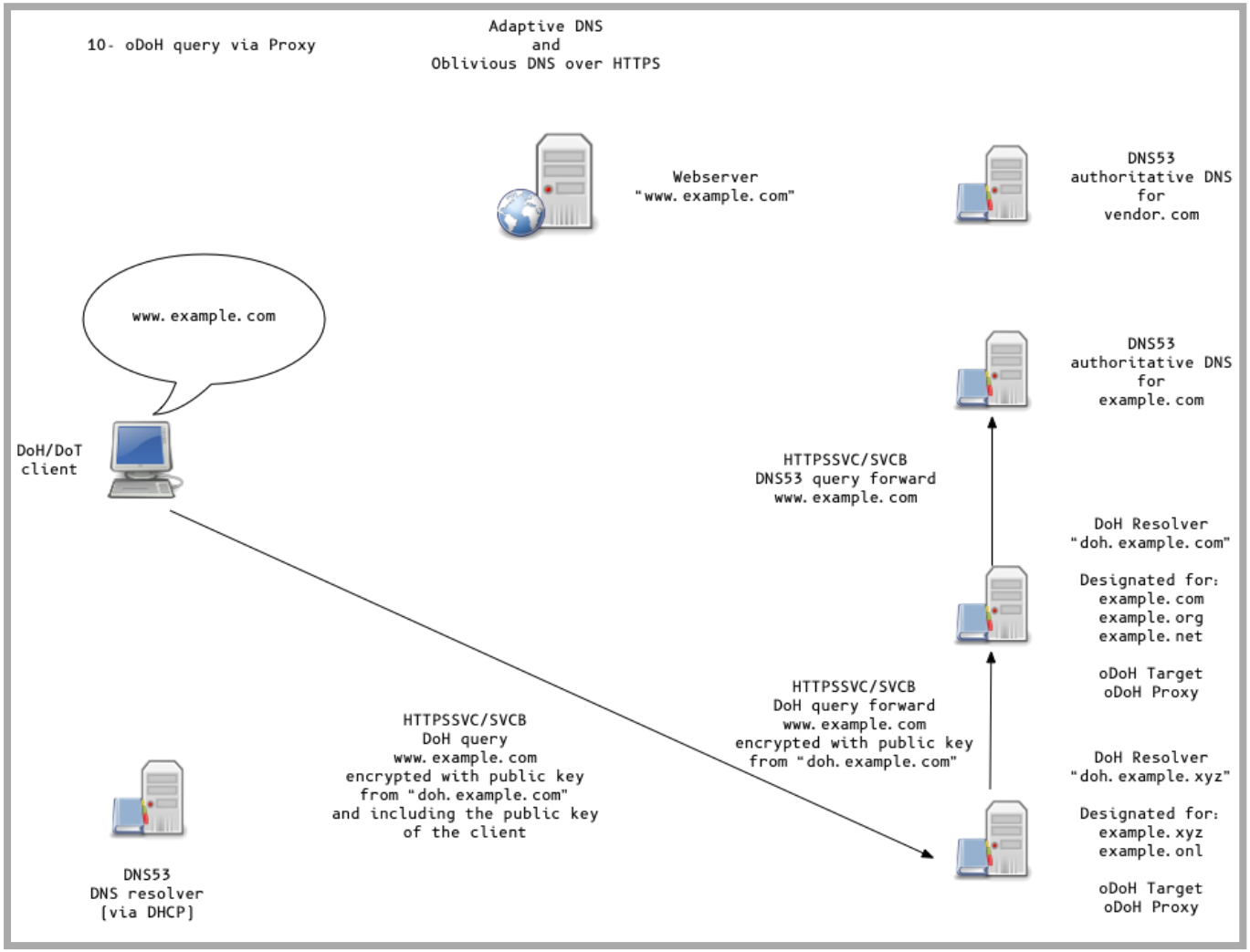

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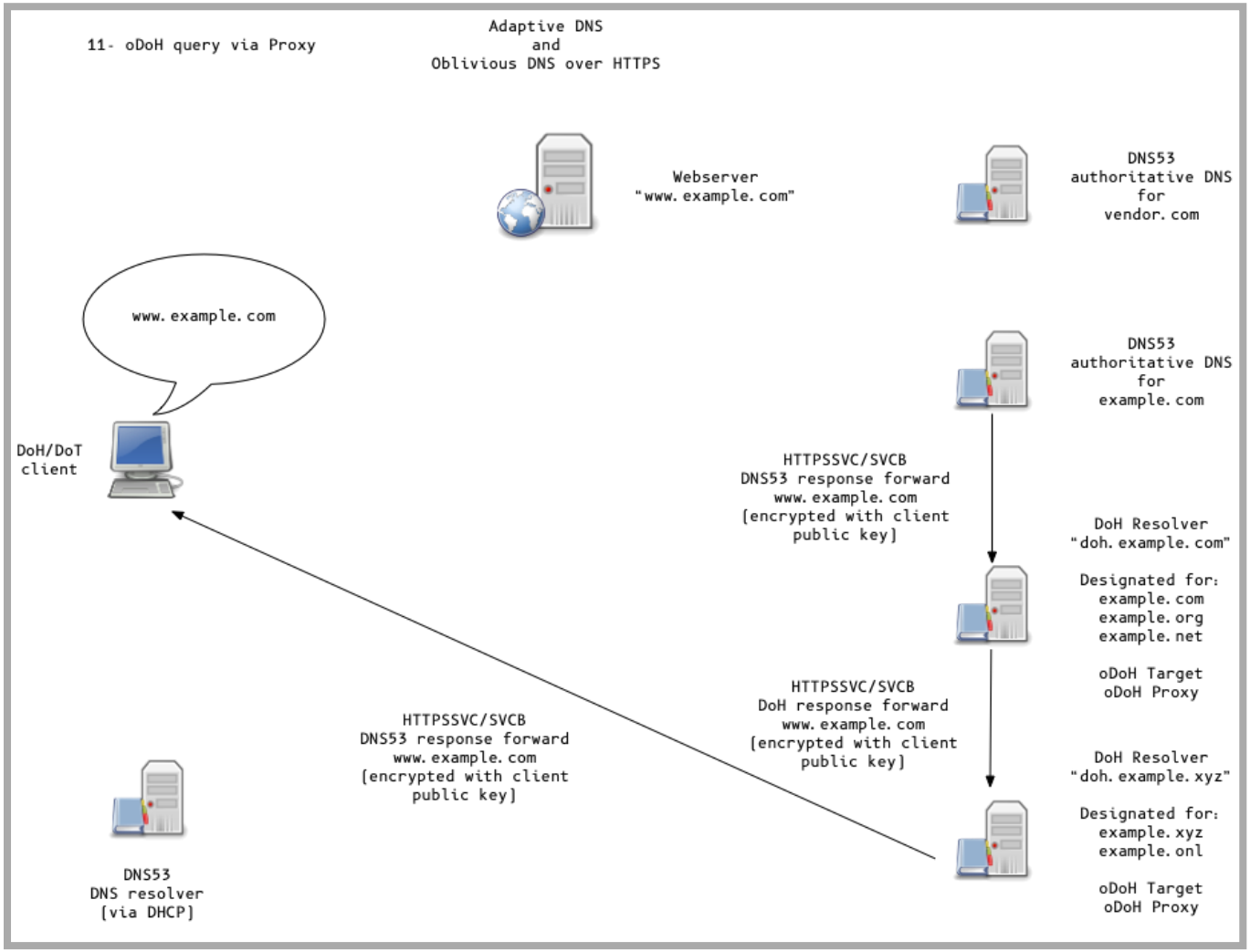

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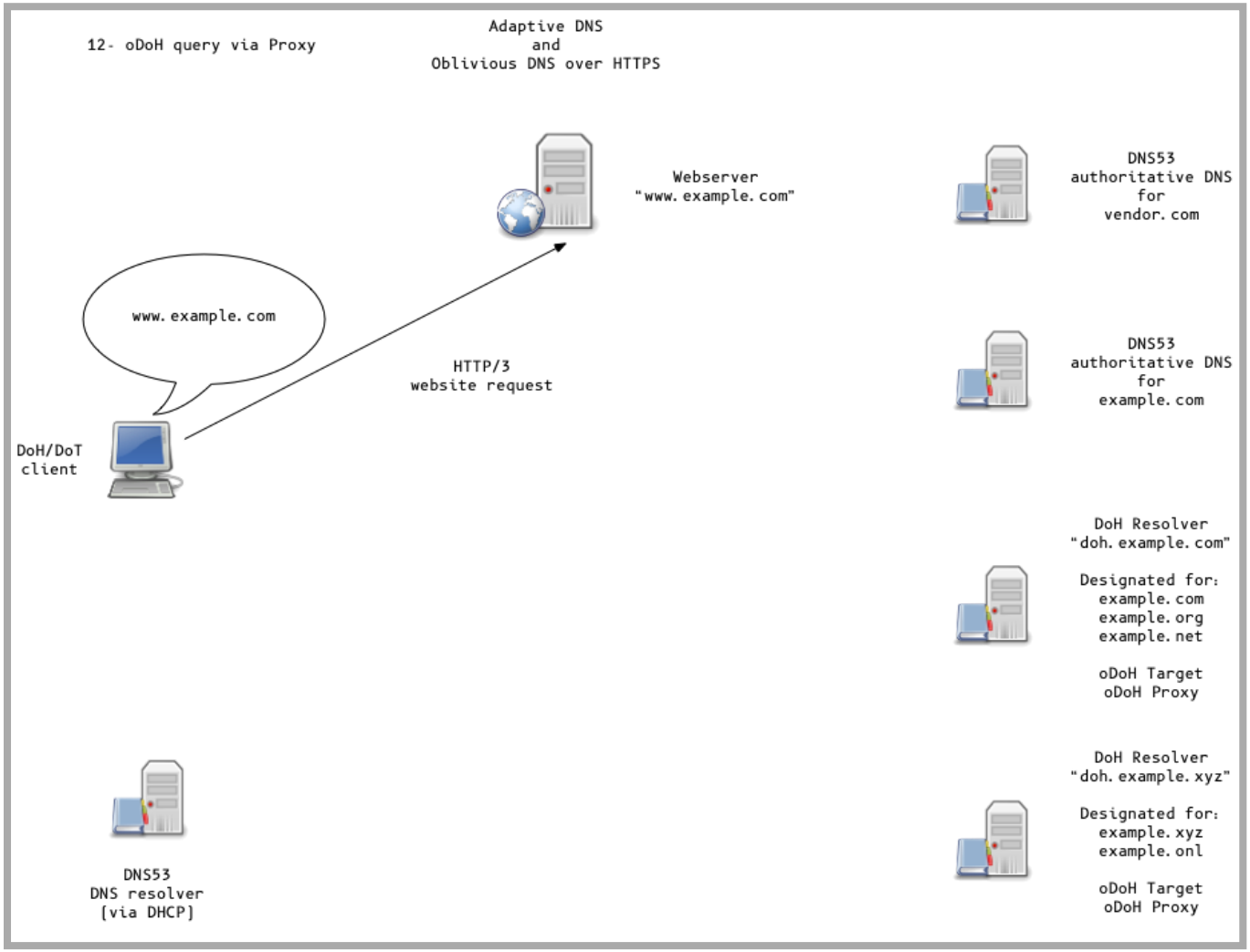

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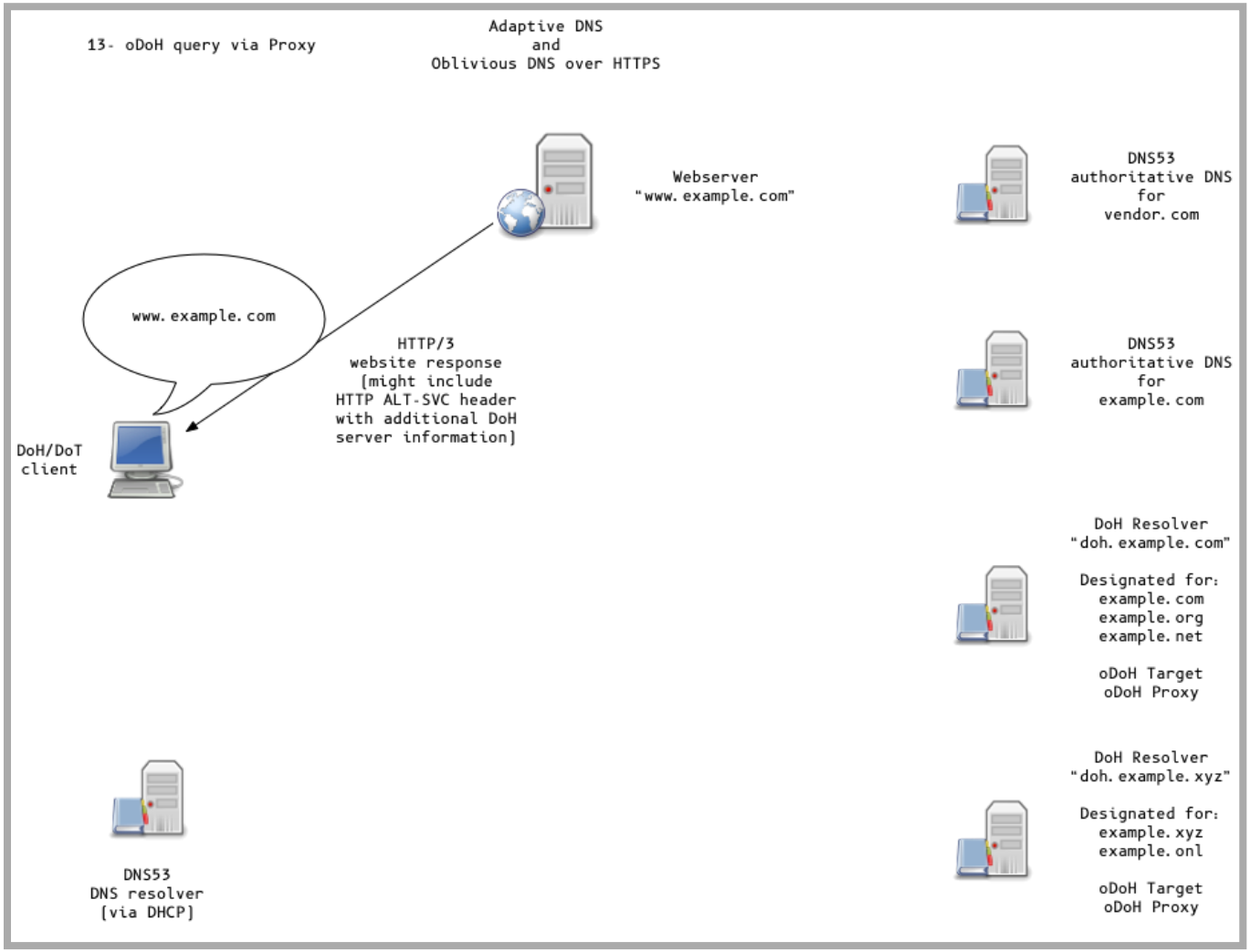

Thank you

Questions

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Links and resources