

LocalRoot++

Making LocalRoot the Default

Disclaimers:

- Joint work with Wes Hardaker, Geoff Huston, Jim Reid, but input from many many others.
- Ongoing discussions in the IETF DNSOP working group.
 - Things are subject to change



Ignaz Semmelweis



(not) Ignaz Semmelweis



A refresher on how resolution works...



How do I reach

www.a-random-domain.net?

Webserver

www.a-random-domain.net

A refresher on how resolution works...

ISP
Resolver



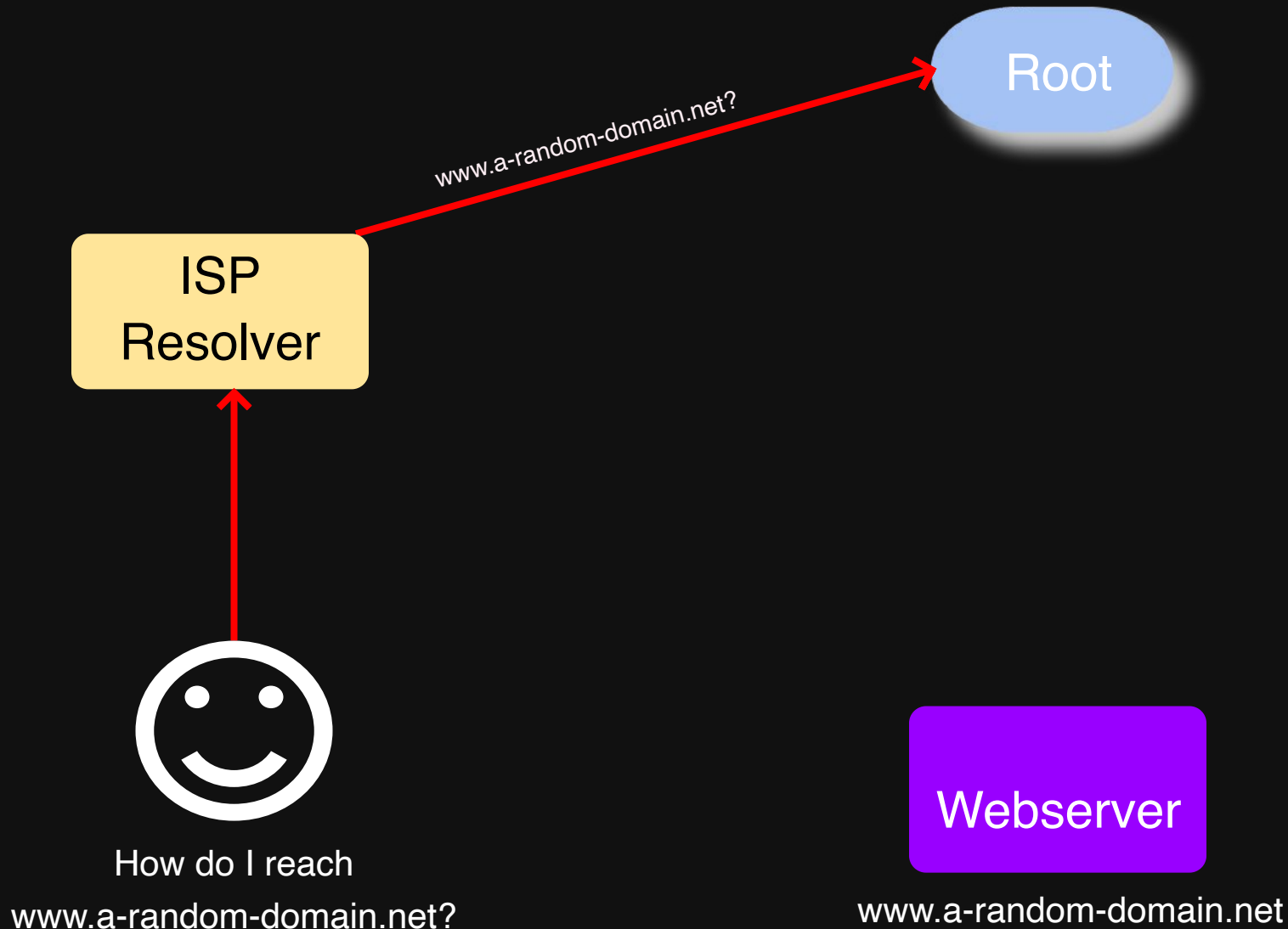
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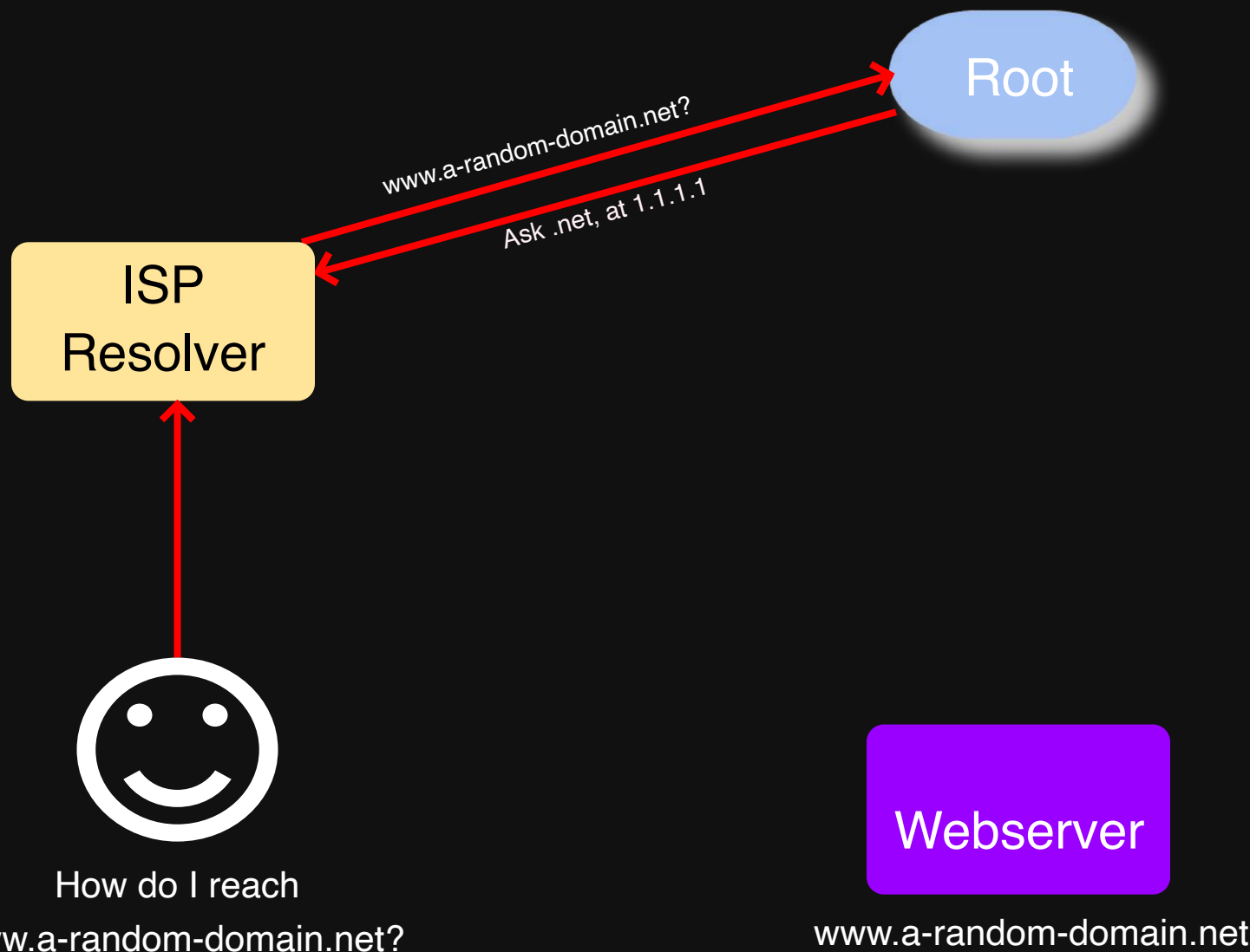
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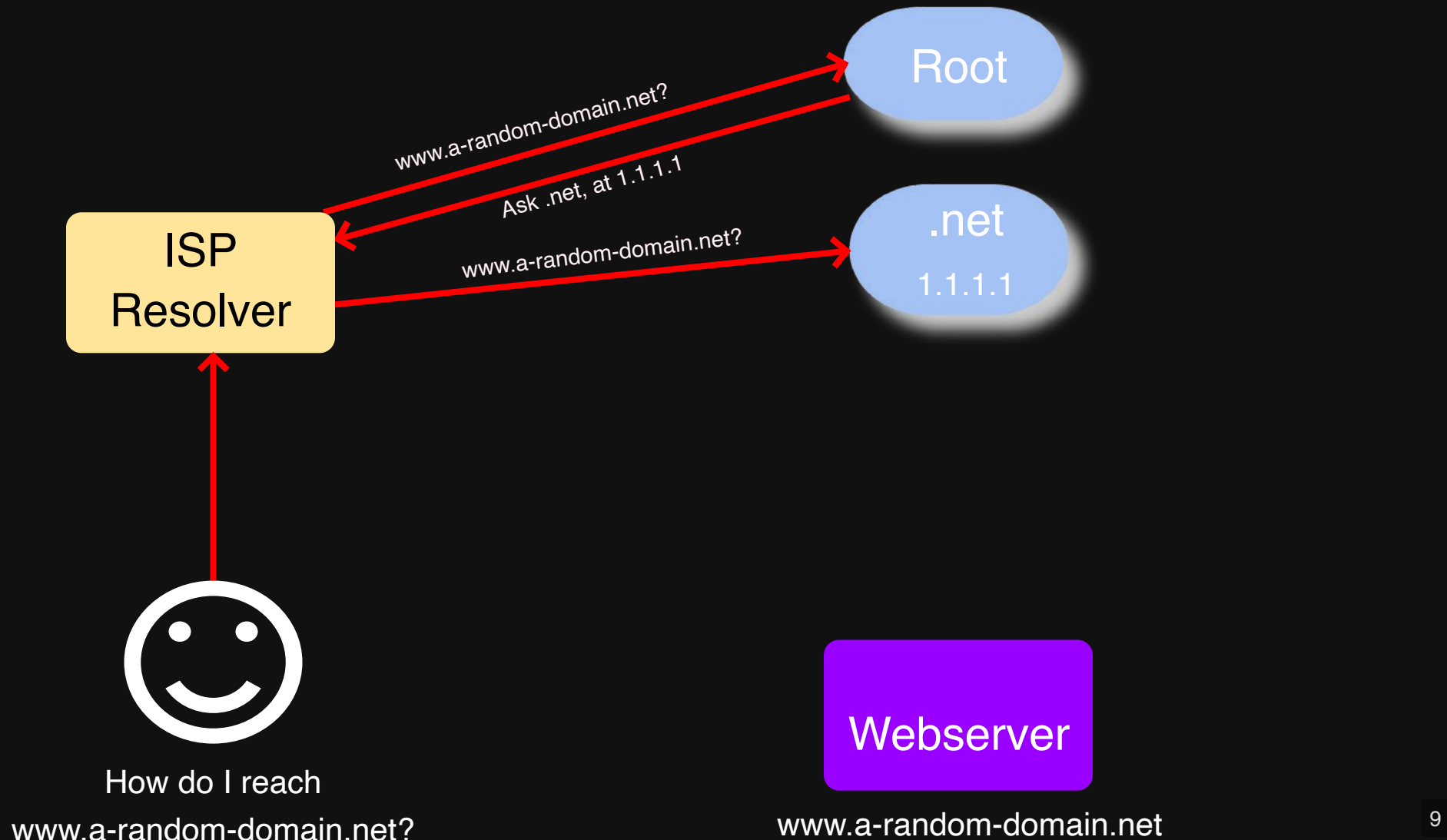
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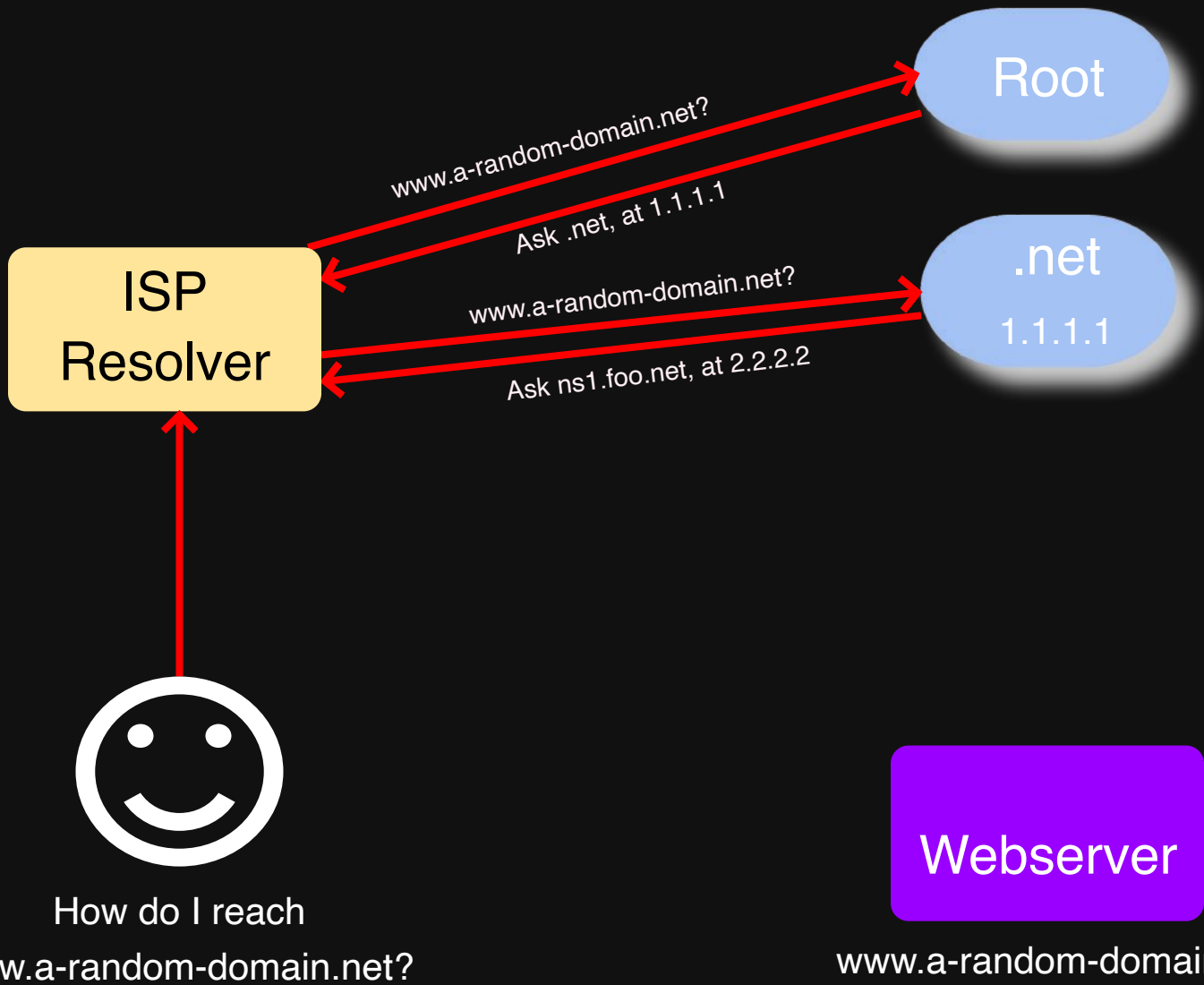
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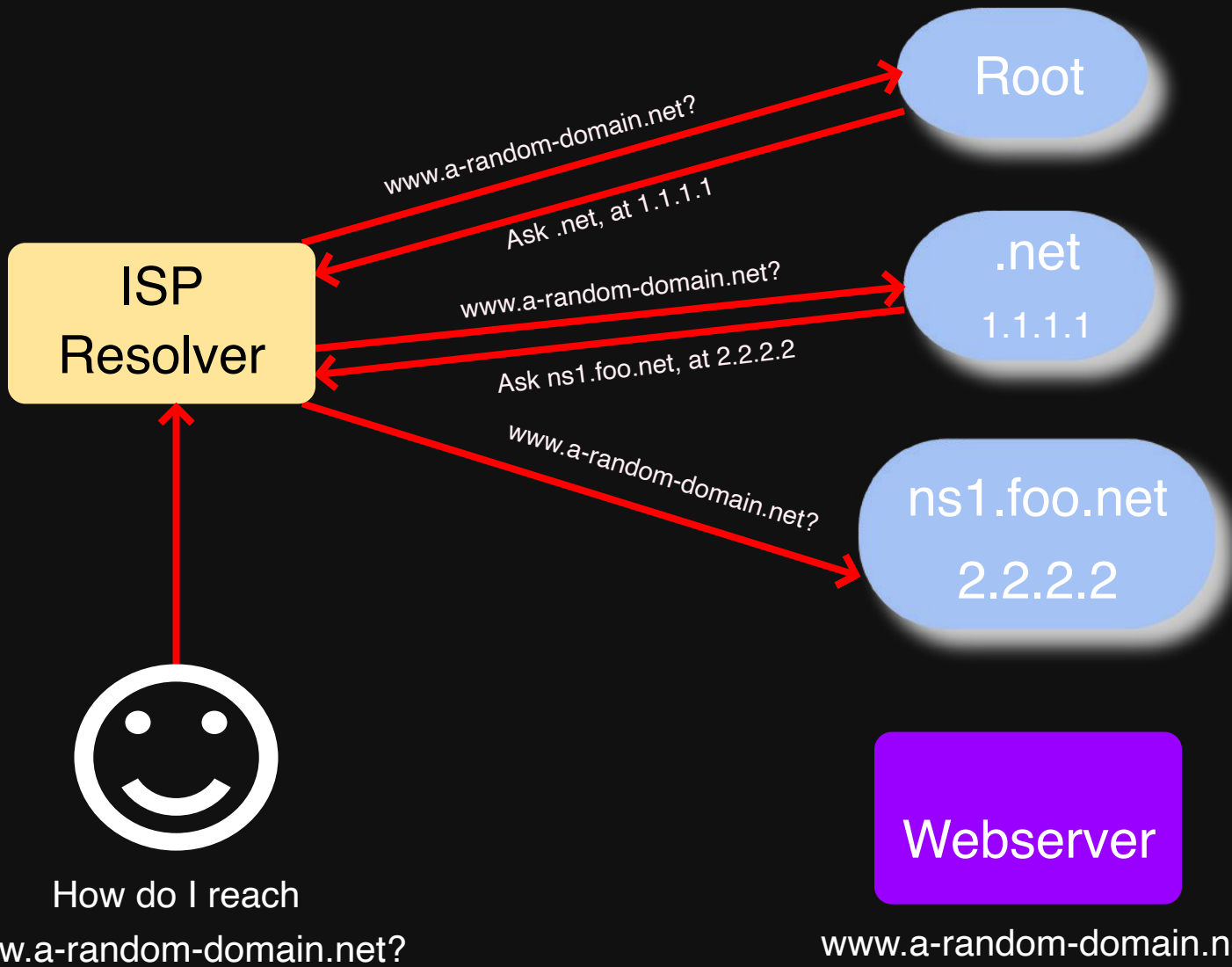
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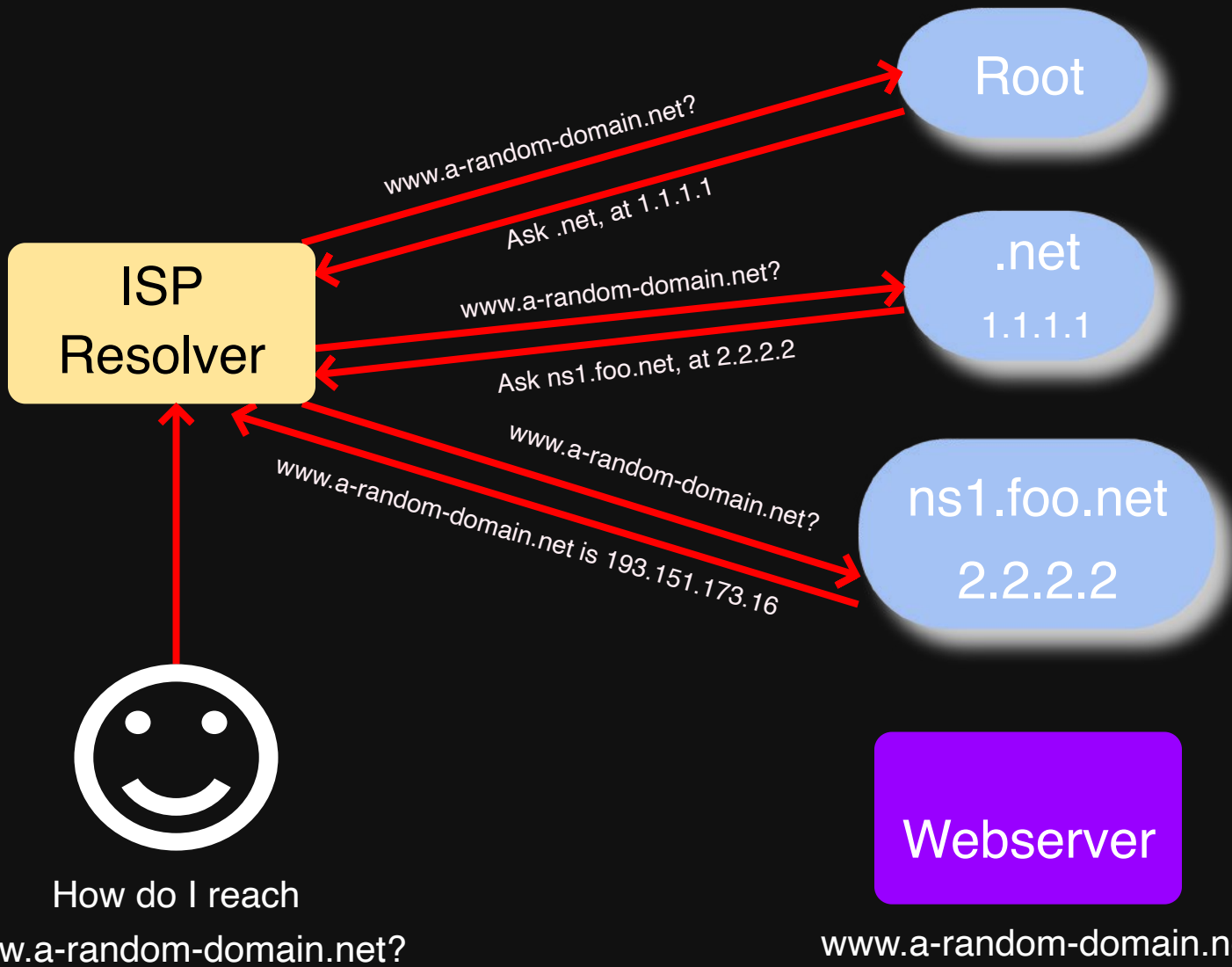
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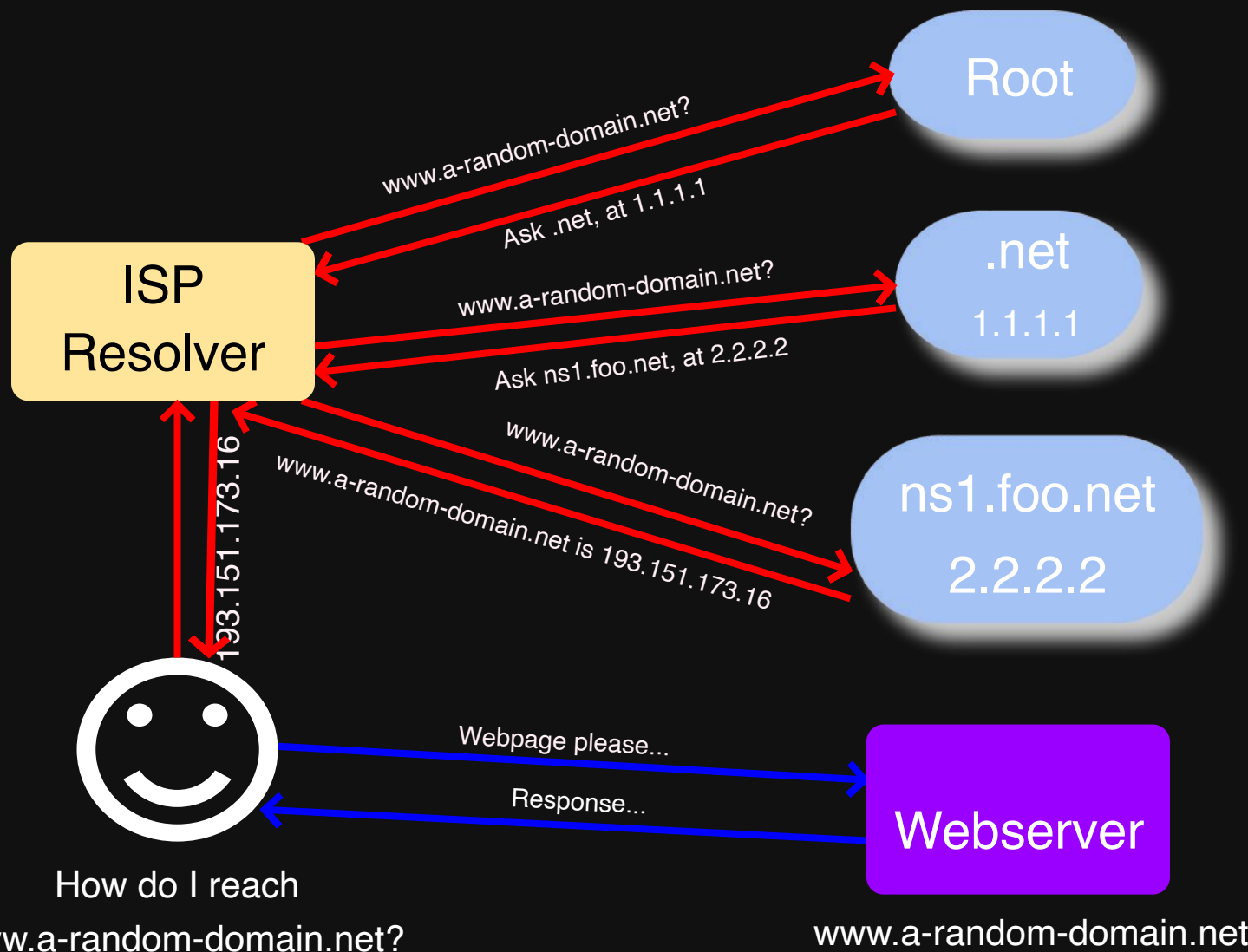
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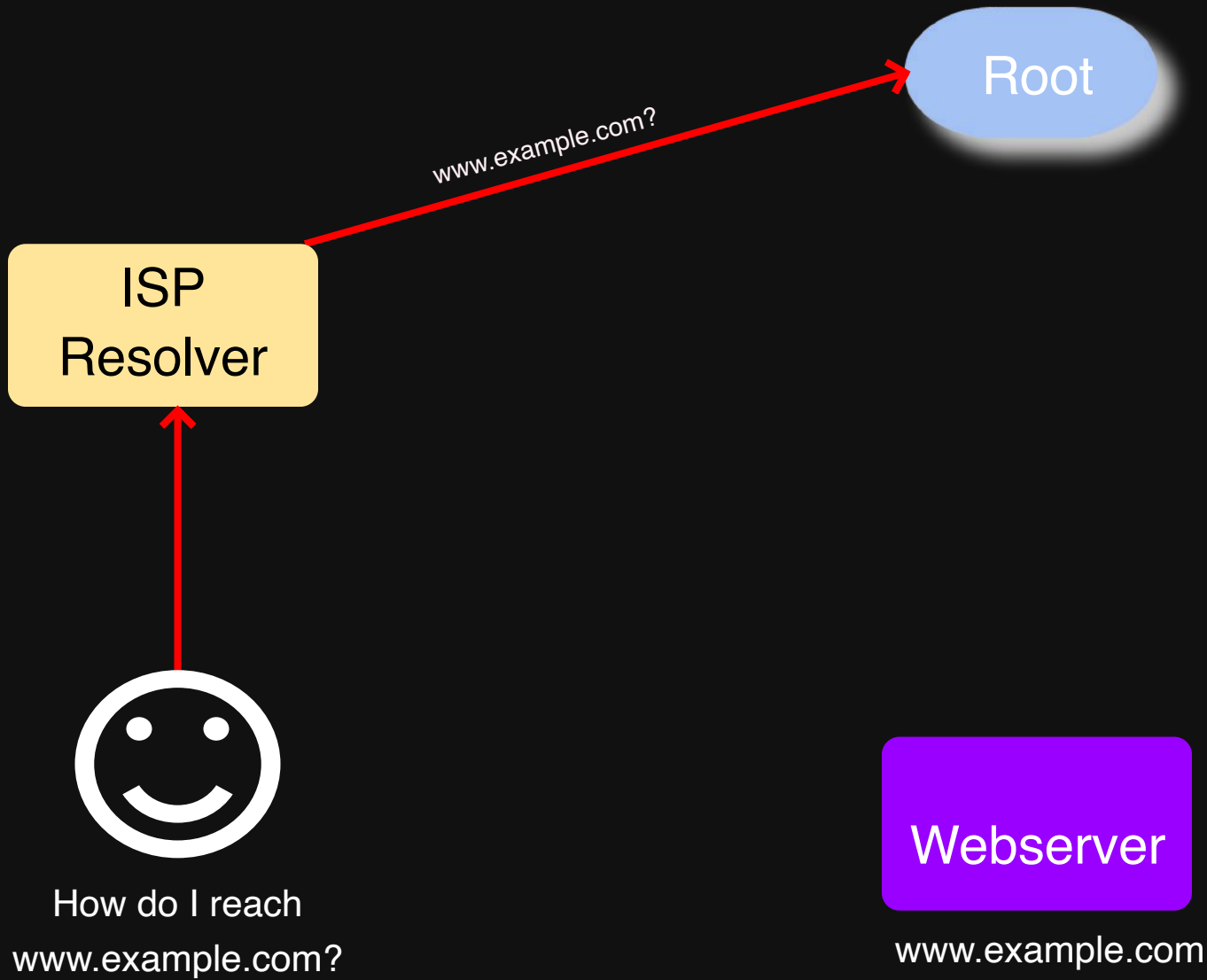


How do I reach
www.example.com?

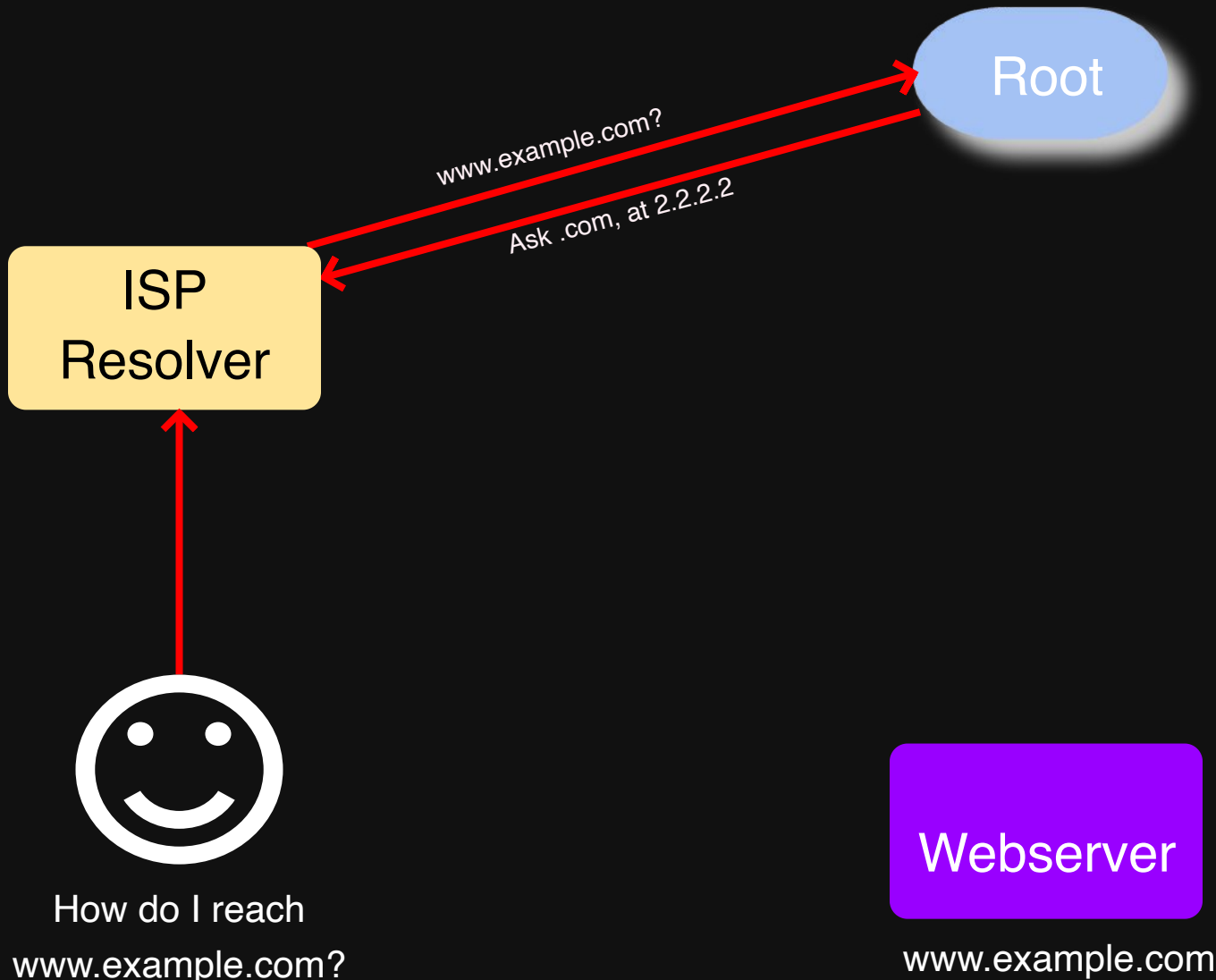
Webserver

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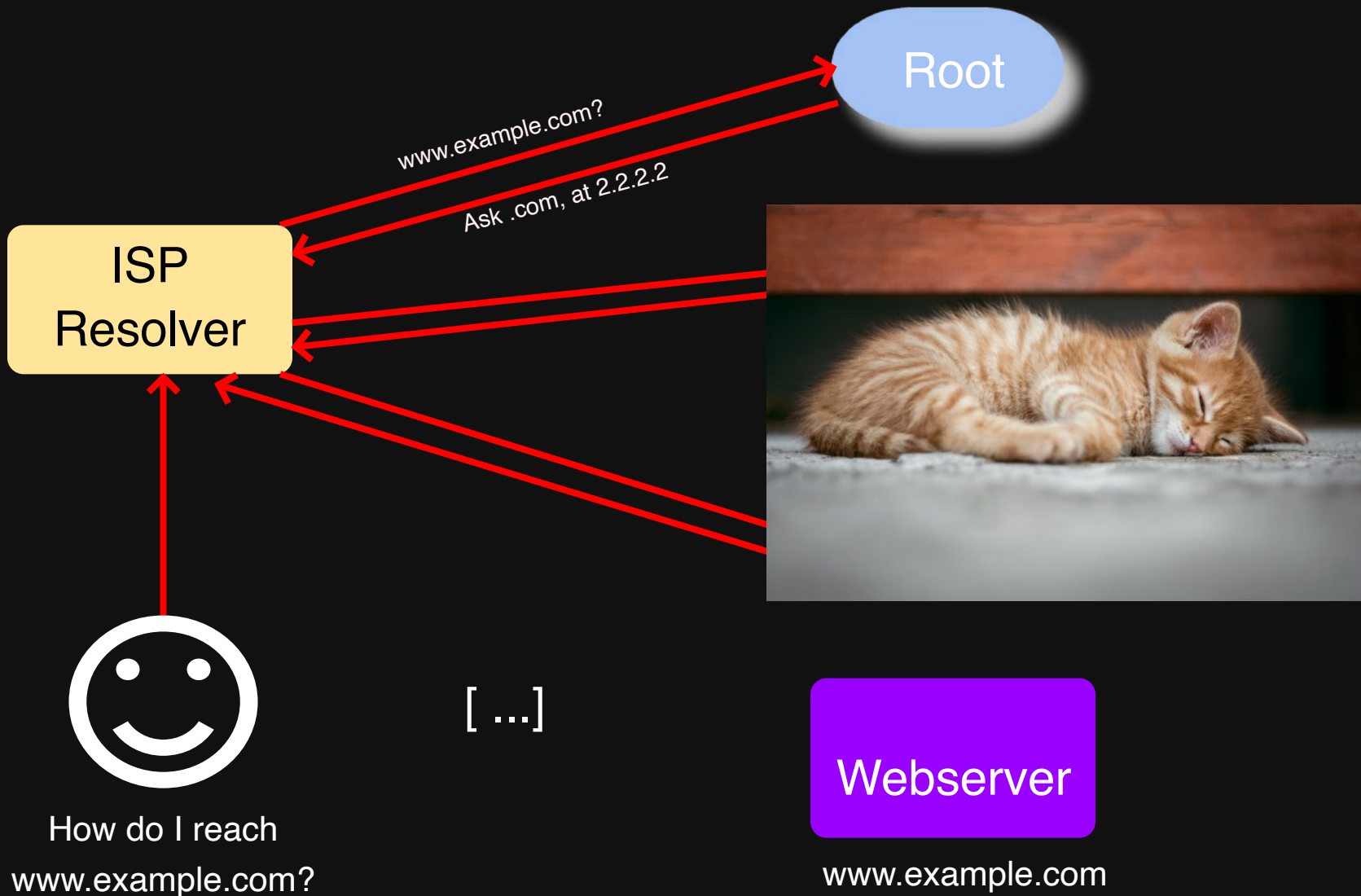
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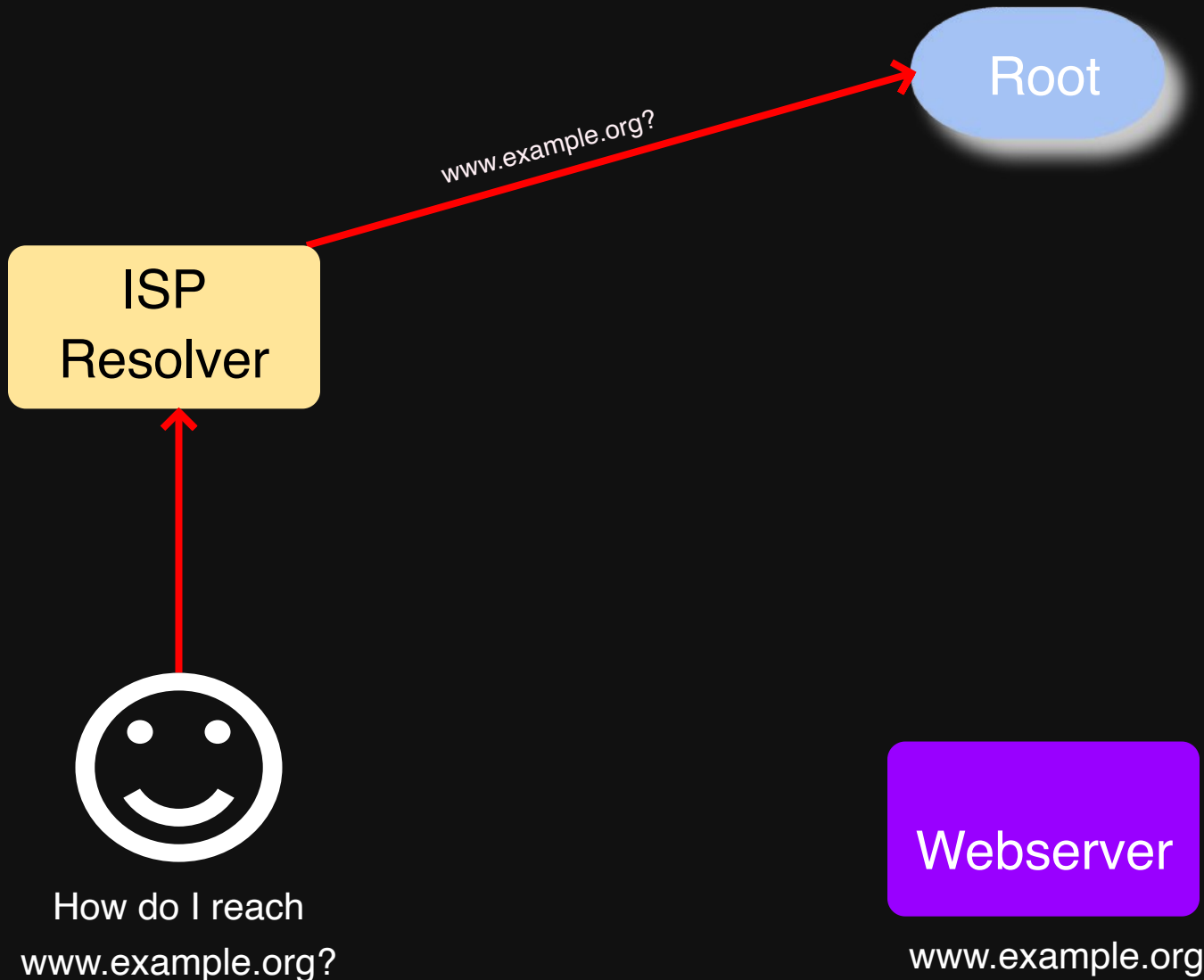


How do I reach
www.example.org?

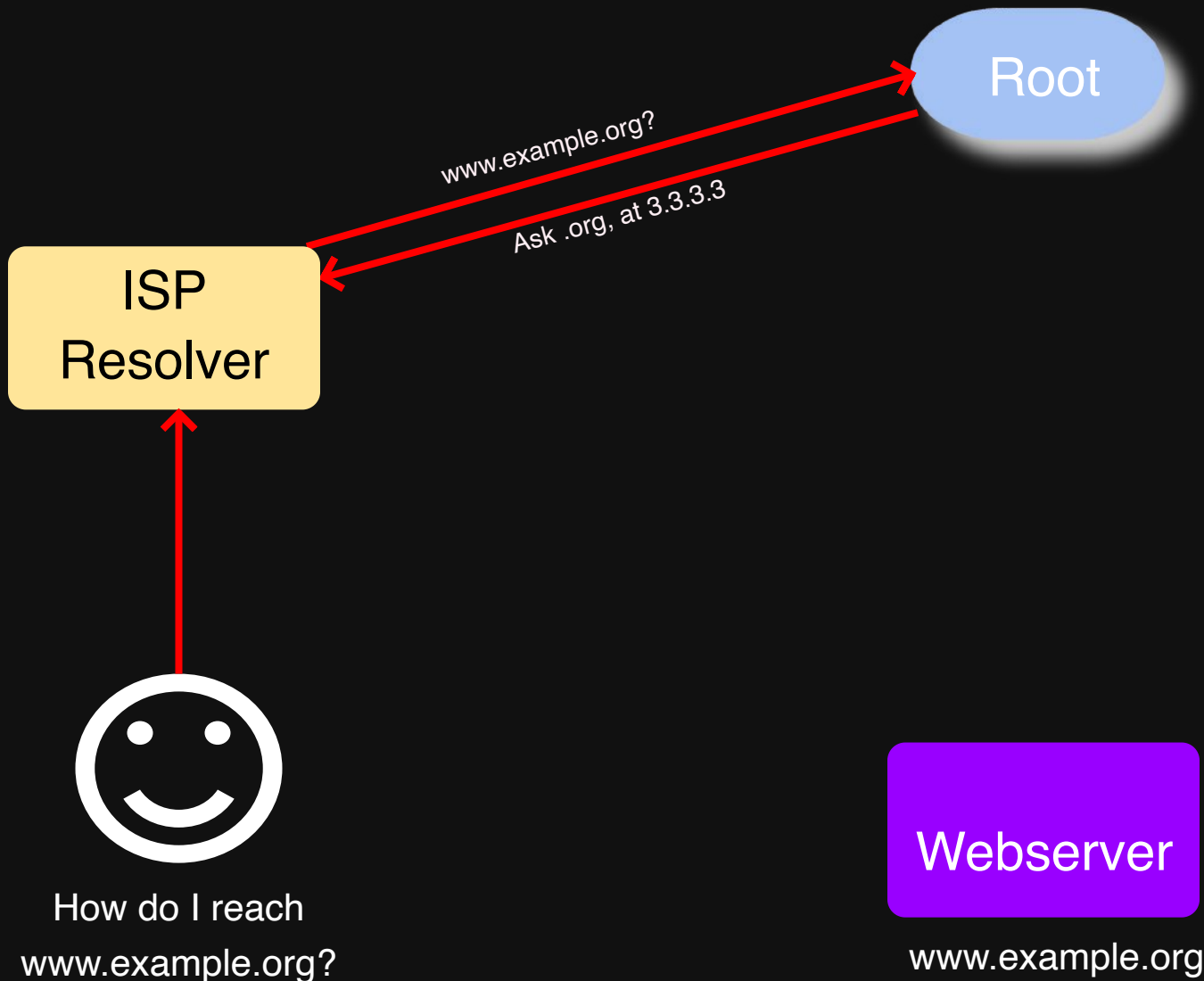
Webserver

www.example.org

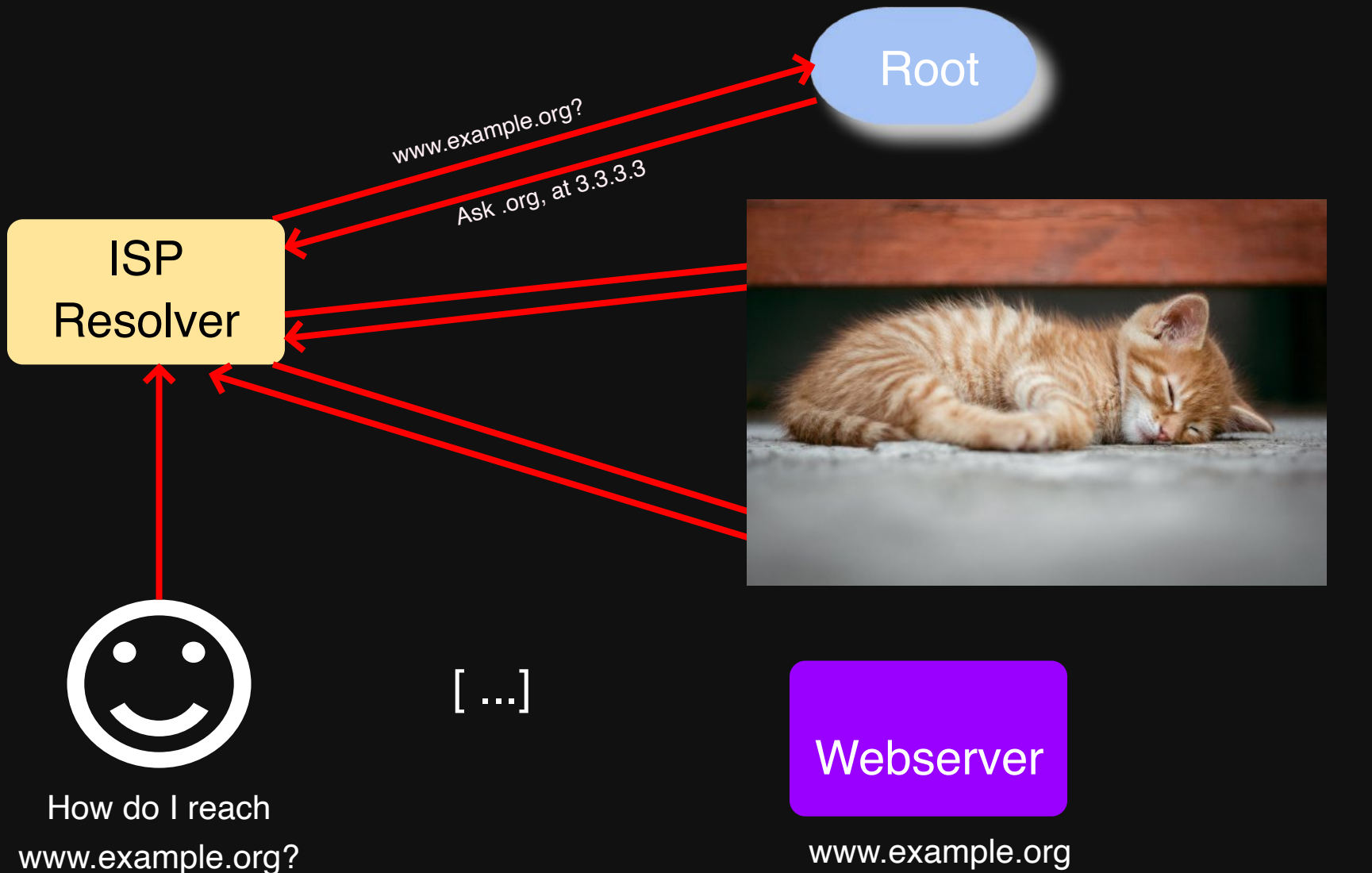
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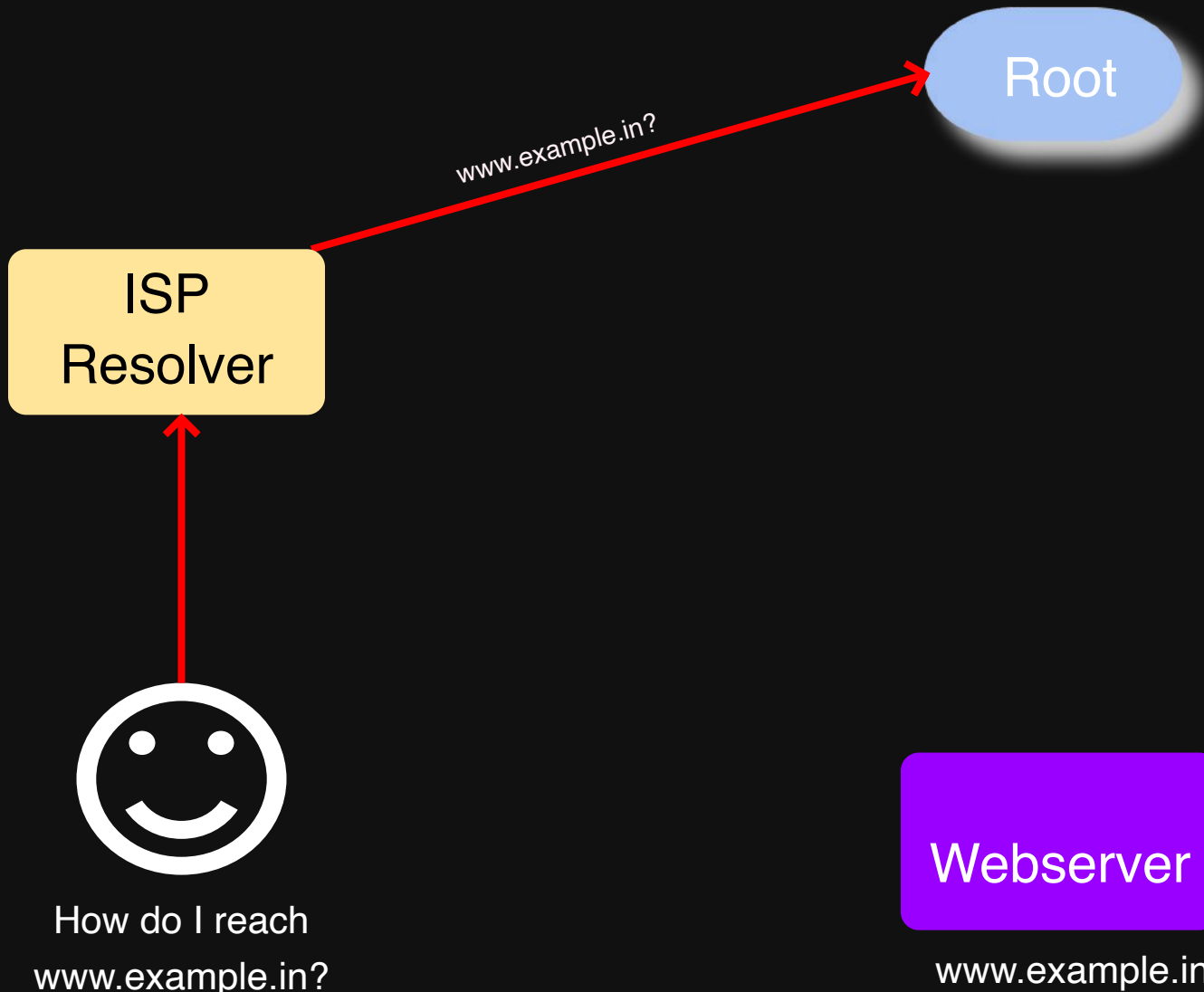


How do I reach
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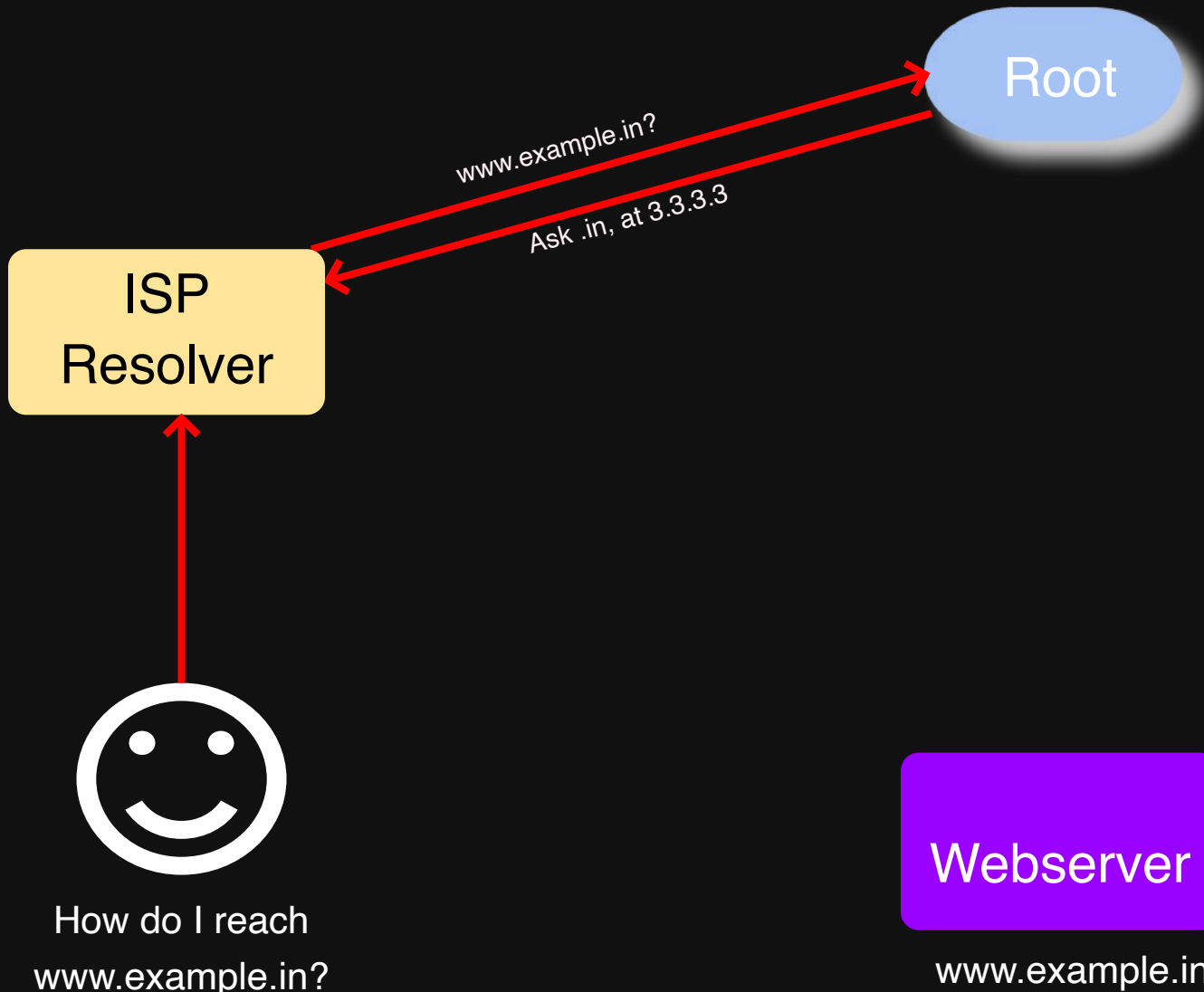
Webserver

www.example.in

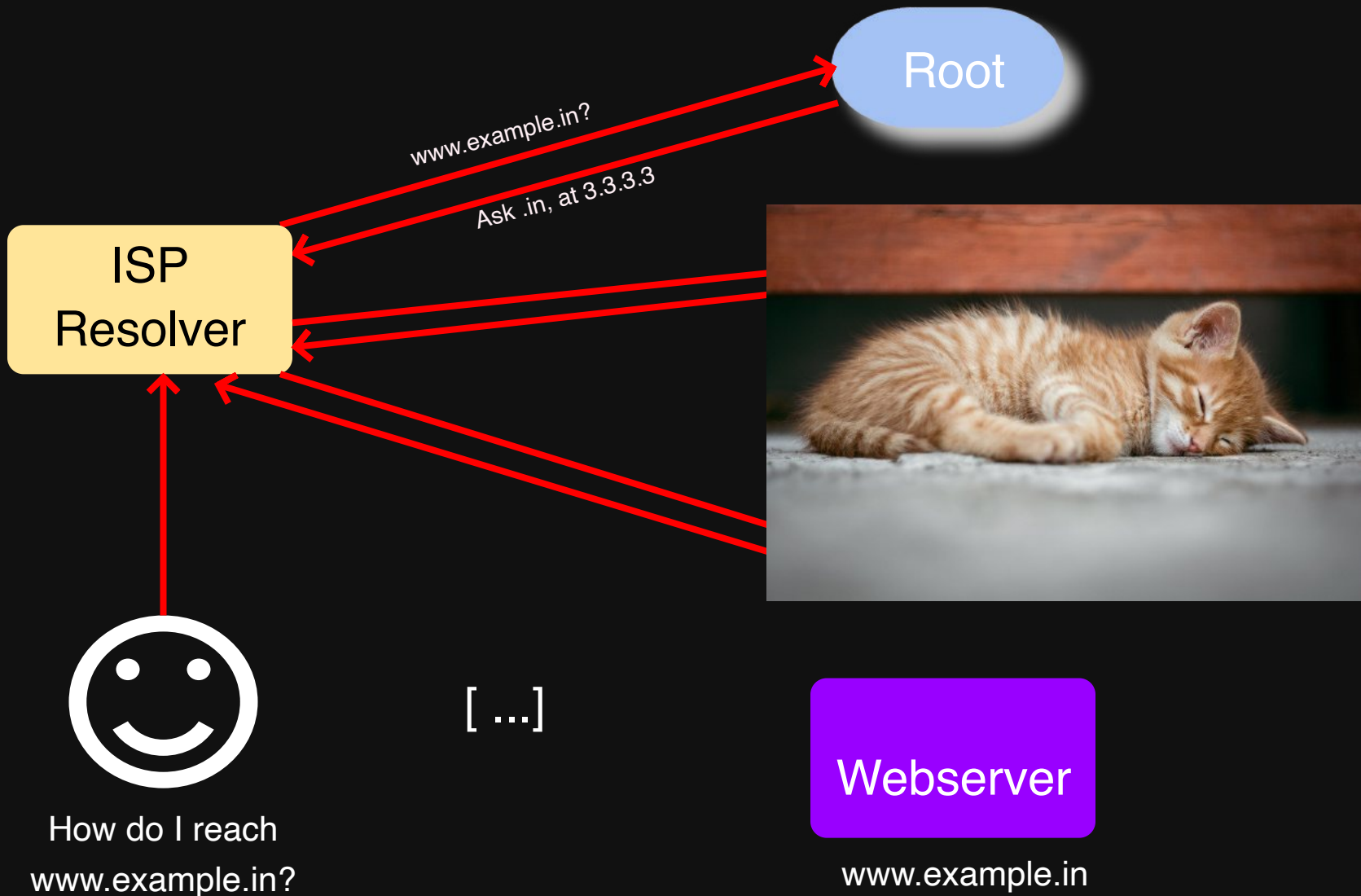
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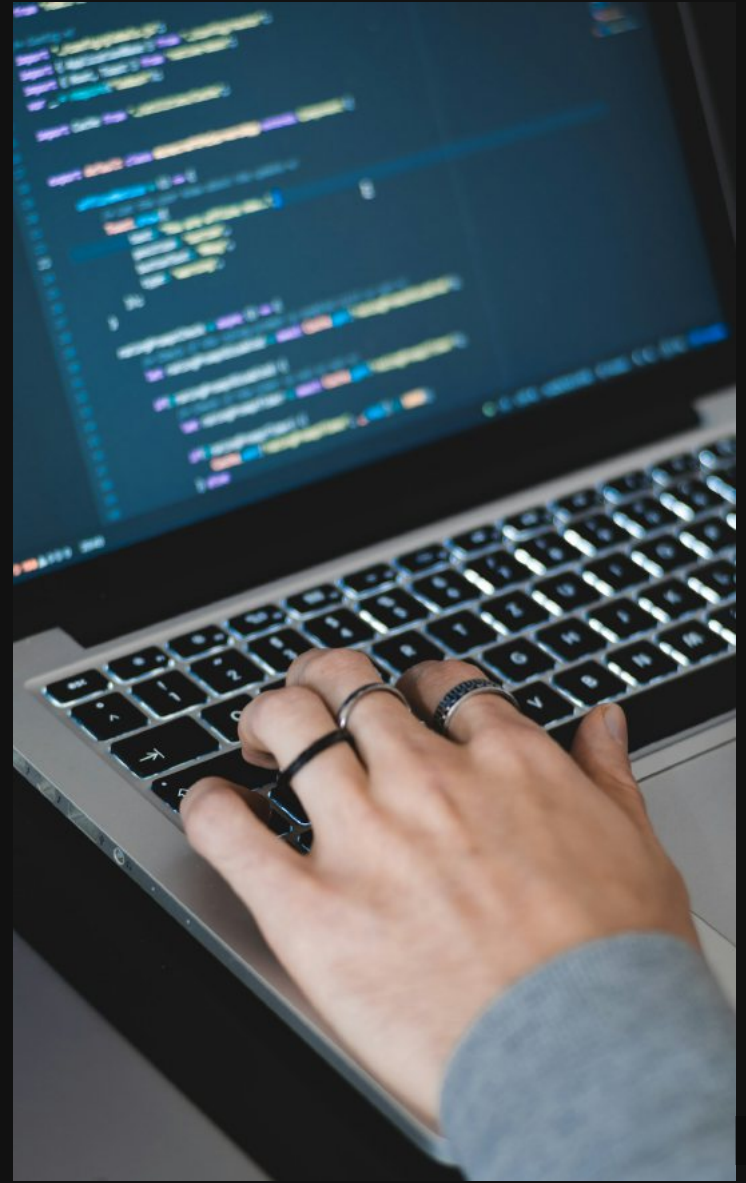
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Wouldn't it be nice...



RFC8806 - "Running a Root Server Local to a Resolver"



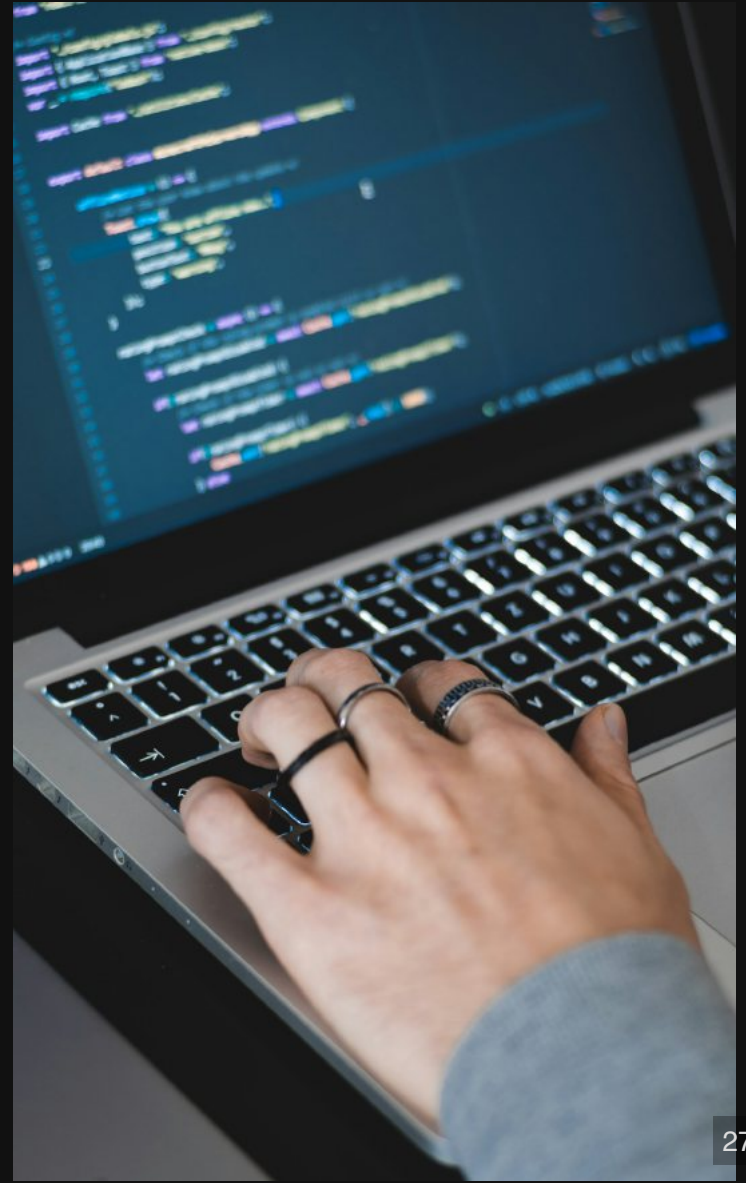
RFC8806 - "Running a Root Server Local to a Resolver"

- Published in 2020, updates RFC7706 from 2015.



RFC8806 - "Running a Root Server Local to a Resolver"

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- Basically: Fetch the root zone and cache it.



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 - Enumeration attacks

How?



Getting the root zone



Internet Assigned Numbers Authority

[Domains](#) [Protocols](#) [Numbers](#) [About](#)

Root Files

Root Hints

Operators who manage a DNS recursive resolver typically need to configure a "root hints file". This file contains the names and IP addresses of the authoritative name servers for the root zone, so the software can bootstrap the DNS resolution process. For many pieces of software, this list comes built into the software.

- [Root Hints File](#) (FTP)
- [Root Hints File](#) (HTTP)

Root Zone File

The complete root zone is available for download at the following locations. Ordinarily there should be no need to download this file on a regular basis, as the contents of the file are served via the DNS system itself.

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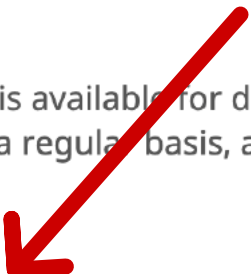
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<https://www.internic.net/domain/root.zone>



Fetching using curl / wget

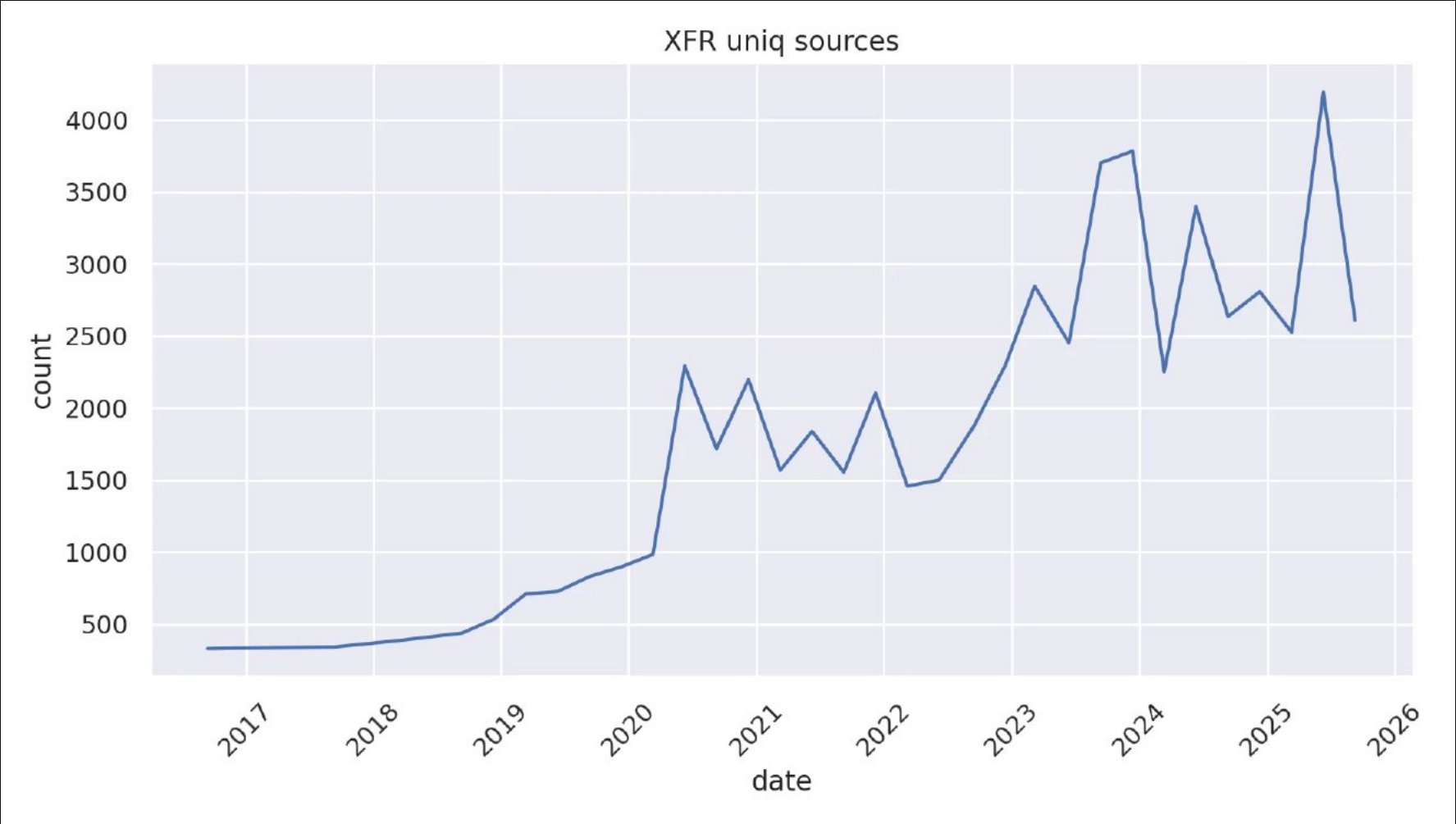
```
● ● ●  
$ wget https://www.internic.net/domain/root.zone  
  
--2025-10-17 11:37:51-- https://www.internic.net/domain/root.zone  
Resolving www.internic.net (www.internic.net)... 192.0.46.9  
Connecting to www.internic.net (www.internic.net)|192.0.46.9|:443... connected.  
HTTP request sent, awaiting response... 200 OK  
Length: 2246592 (2.1M) [text/plain]  
Saving to: 'root.zone'  
  
root.zone                               100%[=====>]    2.14M  2.28MB/s   in 0.9s  
  
2025-10-17 11:37:53 (2.28 MB/s) - 'root.zone' saved [2246592/2246592]
```

Fetching using AXFR

```
● ● ●  
$ dig axfr . @b.root-servers.net  
  
; <<>> DiG 9.10.6 <<>> axfr . @b.root-servers.net  
;; global options: +cmd  
.           86400    IN    SOA  a.root-servers.net. nstld.verisign-grs.com. 2025101700 1800 900 60  
.           518400   IN    NS   a.root-servers.net.  
.           518400   IN    NS   b.root-servers.net.  
.           518400   IN    NS   c.root-servers.net.  
.           518400   IN    NS   d.root-servers.net.  
.           518400   IN    NS   e.root-servers.net.  
.           518400   IN    NS   f.root-servers.net.  
...  
...  
ns1zim.telone.co.zw. 172800 IN  A     41.220.30.81  
ns1zim.telone.co.zw. 172800 IN  AAAA  2c0f:f758:0:a::81  
ns2zim.telone.co.zw. 172800 IN  A     41.220.30.82  
ns2zim.telone.co.zw. 172800 IN  AAAA  2c0f:f758:0:a::82  
.           86400    IN    SOA  a.root-servers.net. nstld.verisign-grs.com. 2025101700 1800 900 60  
;; Query time: 172 msec  
;; SERVER: 170.247.170.2#53(170.247.170.2)  
;; WHEN: Fri Oct 17 11:30:52 EDT 2025  
;; XFR size: 24904 records (messages 86, bytes 1422842)
```

Can fetch from: [b, c, d, f, g].root-servers.net

Fetching using AXFR



ISC BIND 9.14 (and above)

Example configuration using a BIND "mirror" zone:



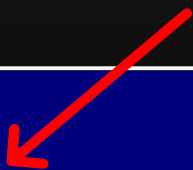
```
zone "." {  
    type mirror;  
};
```

Source: [BIND documentation for mirror zones](#)

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Example configuration using a BIND "mirror" zone:

root zone



```
zone "." {  
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```

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Knot Resolver

Example configuration to prefill cache with root zone using HTTPS:



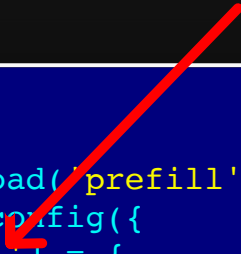
```
modules.load('prefill')
  prefill.config({
    ['.'] = {
      url = 'https://www.internic.net/domain/root.zone',
      interval = 86400 -- seconds
      ca_file = '/etc/pki/tls/certs/ca-bundle.crt', -- optional
    }
  })
```

Source: [Knot Resolver Cache prefilling](#)

Knot Resolver

Example configuration to prefill cache with root zone using HTTPS:

zone



```
modules.load('prefill')
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Source: Knot Resolver Cache prefilling

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Optional TLS

Source: Knot Resolver Cache prefilling

Unbound 1.9 (and above)

Unbound Auth Zones example:

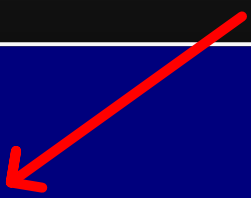
```
auth-zone:
  name: "."
  url: "https://www.internic.net/domain/root.zone"
  zonefile: "root.zone"
    fallback-enabled: yes
  for-downstream: no
  for-upstream: yes
  zonefile: "root.zone"
  prefetch: yes
```

Source: [Unbound Authority Zone Options](#)

Unbound 1.9 (and above)

Unbound Auth Zones example:

root zone



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auth-zone:
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  zonefile: "root.zone"
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  for-downstream: no
  for-upstream: yes
  zonefile: "root.zone"
  prefetch: yes
```

Source: Unbound Authority Zone Options

So, how much data is this?!



Individual queries



```
sudo ipset destroy root_servers
sudo ipset -N root_servers iphash
```

```
sudo ipset -A root_servers 198.41.0.4
sudo ipset -A root_servers 170.247.170.2
...
```

```
sudo iptables -A INPUT -m set --match-set root_servers src -j ACCEPT
```

```
sudo unbound-control flush_zone .
sudo iptables -L -Z -v
```

[Query each TLD]

```
sudo iptables -L -vv
sudo iptables -L -vvv
ip filter INPUT 8
```

```
[ match name set rev 4 ]
[ counter pkts 1537 bytes 1127567 ]
[ immediate reg 0 accept ]
```

Chain INPUT (policy ACCEPT 21512 packets, 5564K bytes)

pkts	bytes	target	prot	opt	in	out	source	destination	mat
1537	1128K	ACCEPT	all	--	any	any	anywhere	anywhere	mat
0	0	ACCEPT	all	--	any	any	anywhere	anywhere	mat

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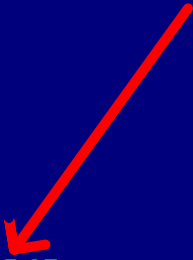
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1.1MB



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AXFR



```
dig axfr . @b.root-servers.net
```

Bytes: 1,602,476 (2719 packets)

HTTP

HTTPS



```
wget https://www.internic.net/domain/root.zone
```

Bytes: 2,379,902

HTTP

HTTPS



```
wget https://www.internic.net/domain/root.zone
```

Bytes: 2,379,902

HTTPS with nginx - gzip



```
wget https://www.owl-stretching-time.com/root.zone
```

Bytes: 990,949

CDNs - Content Delivery Network

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- Specifically designed to distribute web objects

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- Basically every webpage and video is served from a CDN

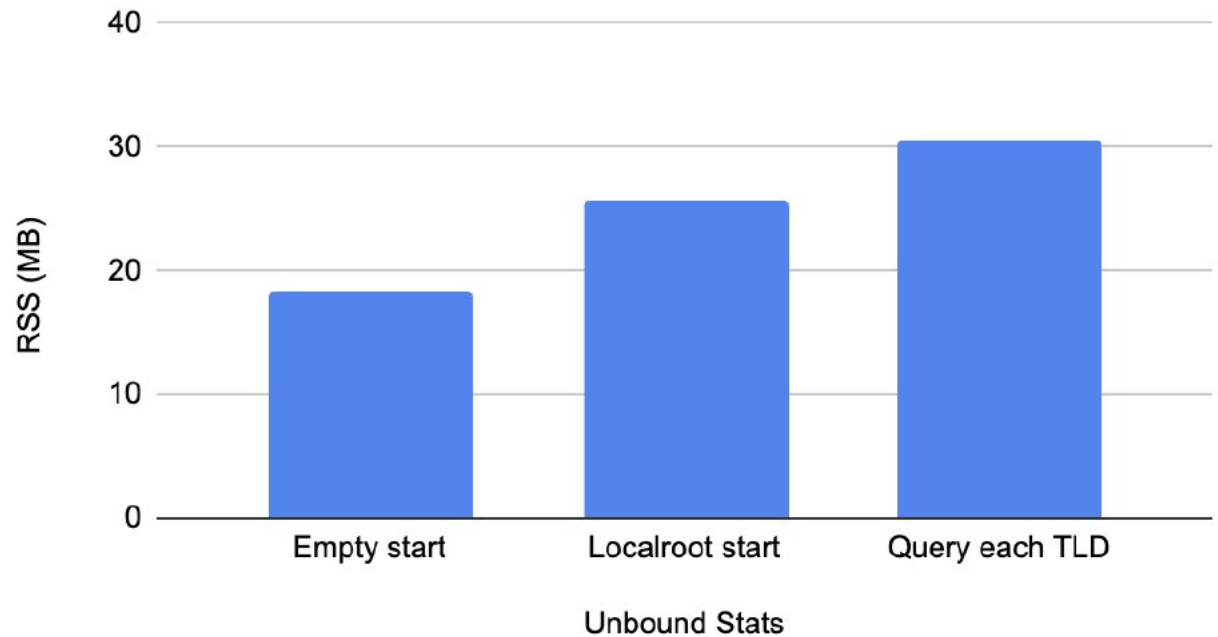
CDNs - Content Delivery Network

- Specifically designed to distribute web objects
- Basically every webpage and video is served from a CDN
- Designed for high scalability, geographic distribution

Capacity

Recursive Resolvers	1,000,000
Zone Size (MB)	2.5
Zone Size (GZIP MB)	0.9
Updates per Day	3
Uncompressed	
Total Data (Day)	7 TB
Total Data (Month)	222 TB
GZIP Compressed	
Total Data (Day)	3 TB
Total Data (Month)	80 TB
Rate (Transfers / sec)	34.72

RSS (MB) vs. Unbound Stats



Trust...



RFC 8976 - "Message Digest for DNS Zones"

- "... an RR type that provides a cryptographic message digest of the data in a zone."
- Also known as "ZONEMD"
- DNSSEC signature over the entire zone file

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```
1  $ dig zonemd .
2
3  ; <<>> DiG 9.18.39-0ubuntu0.24.04.2-Ubuntu <<>> zonemd .
4  ;; global options: +cmd
5  ;; Got answer:
6  ;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 9730
7  ;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1
8
9  ;; OPT PSEUDOSECTION:
10 ; EDNS: version: 0, flags:; udp: 65494
11 ;; QUESTION SECTION:
12 ;.                IN  ZONEMD
13
14 ;; ANSWER SECTION:
15 .                86400  IN  ZONEMD  2025102400 1 1 9679D824471ED710F3C6332217D1A70A96757F564D
16
17 ;; Query time: 22 msec
```

draft-wkumari-dnsop-localroot-bcp

New document(s) provide:

- A list of places to fetch from
 - And algorithm (AXFR, HTTPS, ...)
- Procedures for updating this list
- Relaxing the implementation requirements
 - What to do (have the root zone locally), not how to do it (removed the "Thou must run an authoritative server...")
- Clarifications on fallback, resilience, etc.

draft-wkumari-dnsop-localroot-bcp

1. Identify locations from where root zone data can be obtained (Section 3.1).
 2. Downloading and refreshing the root zone data from one of the publication points (Section 3.2).
 3. Integrating and serving the data while performing DNS resolutions (Section 3.3).
- Has new text on retries, fallback and fetching by IP, where and how to get the zone, etc.

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Yes, I'm aware of RFC7816 - "DNS Query Name Minimisation to Improve Privacy" and RFC8198 - "Aggressive Use of DNSSEC-Validated Cache" (I'm an author)

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- DoS Mitigation
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- Reduce criticality of the Root Server System

Yes, I'm aware of RFC7816 - "DNS Query Name Minimisation to Improve Privacy" and RFC8198 - "Aggressive Use of DNSSEC-Validated Cache" (I'm an author)

Questions?



Backup slides

Capacity

- Comparison to current root-server system
 - **One** CDN states 405Tbps
 - Current RSS: 1999 instances (2025-10-19)
 - That means each instance would need 202Gbps to match



Google

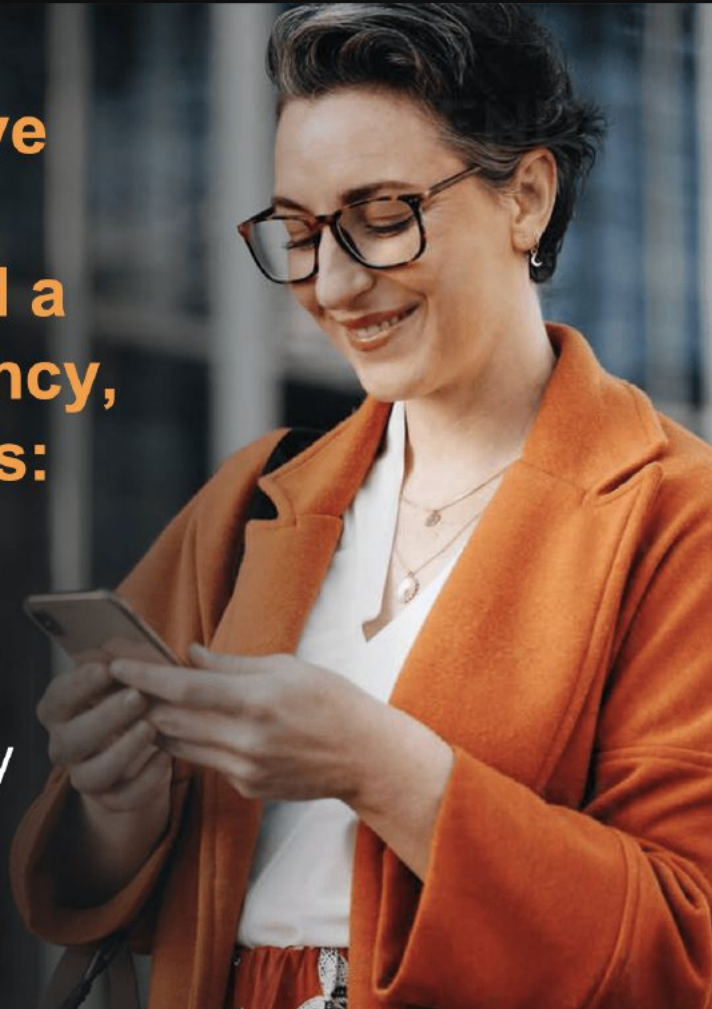


Cloudflare

Capacity

Through massive distribution, full automation, and a focus on efficiency, Akamai provides:

Better performance
Greater scalability
Much higher reliability
Lower cost



1,000
TBPS OF CAPACITY

4,100+
EDGE PoPs

1,200+
NETWORKS

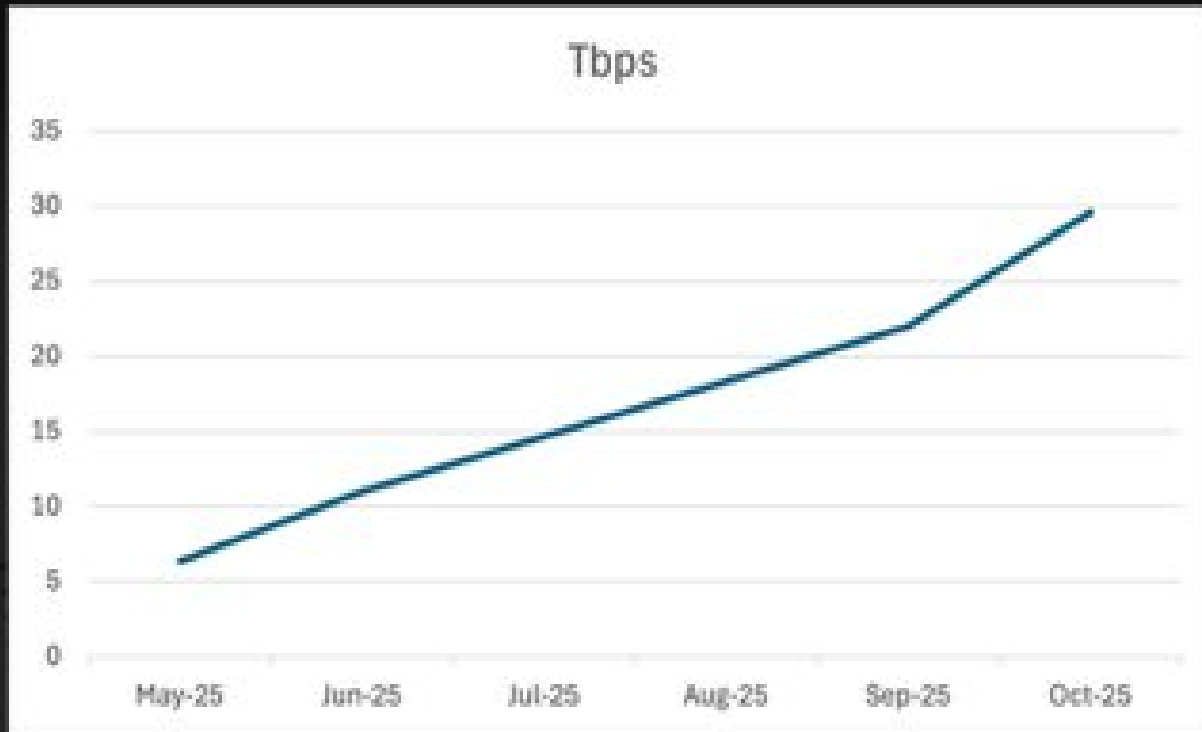
750+
CITIES

130
COUNTRIES

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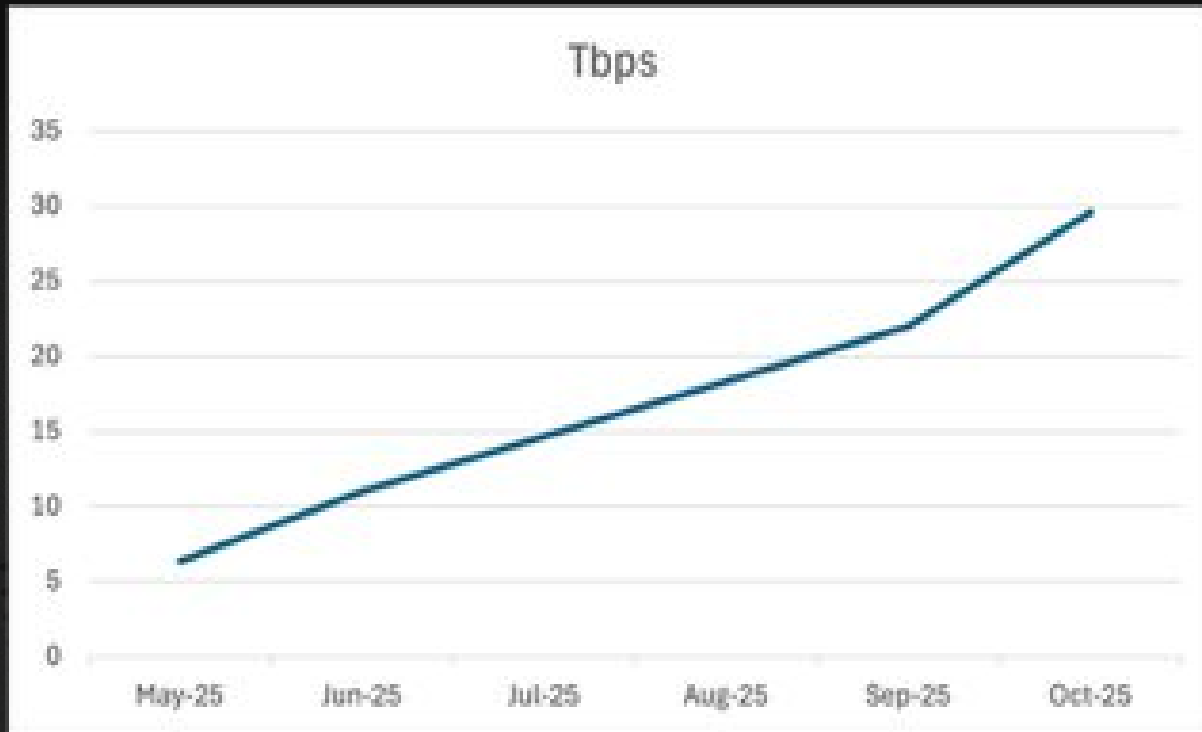
Source: Akamai's Vision and Strategy Dr. Tom Leighton, Akamai CEO

DDoS Capacity



Aisuru

DDoS Capacity

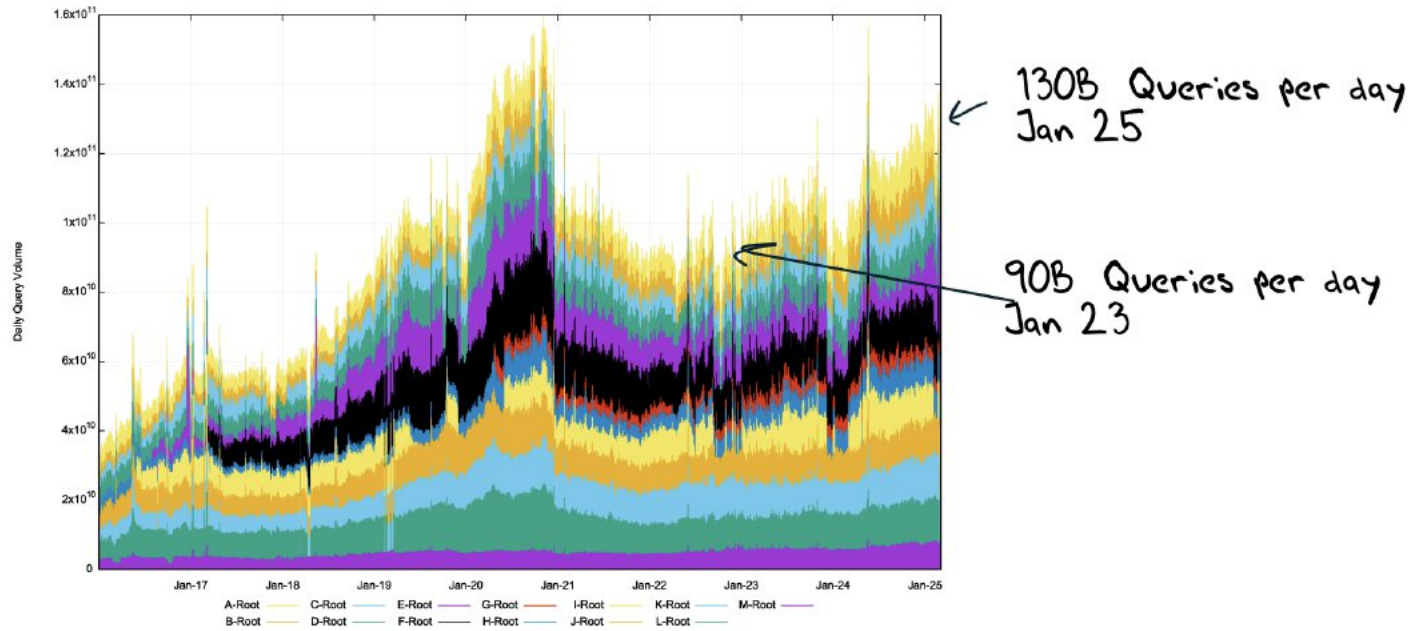


Aisuru

- 30 Tbps / 1998 instances = ~ 15Gpbs / instance

Root Query

Root Query Load



From <https://github.com/rssac-caucus/RSSAC002-data>