CSCI 466: Networks

Lecture 7: DNS

Reese Pearsall

Fall 2023

Announcements

Quiz 2 on Friday (no lecture)

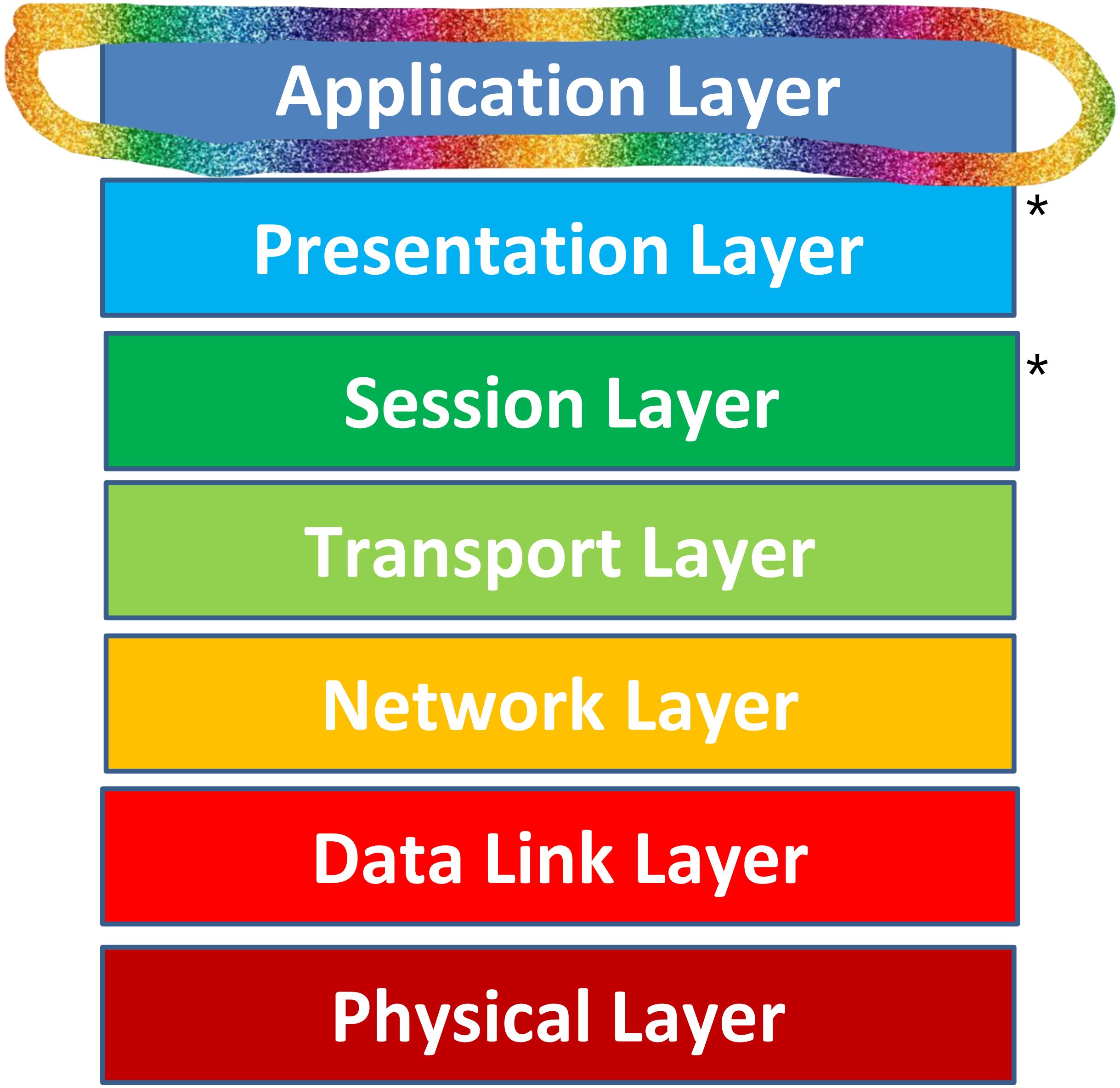
- HTTP
- TCP/UDP Sockets
- DNS

12:00 – 5:00 PM Window

Wireshark Lab 1 due **9/20**

PA1 Posted, due on **September 27th**

OSI Model



Application Layer

Presentation Layer *

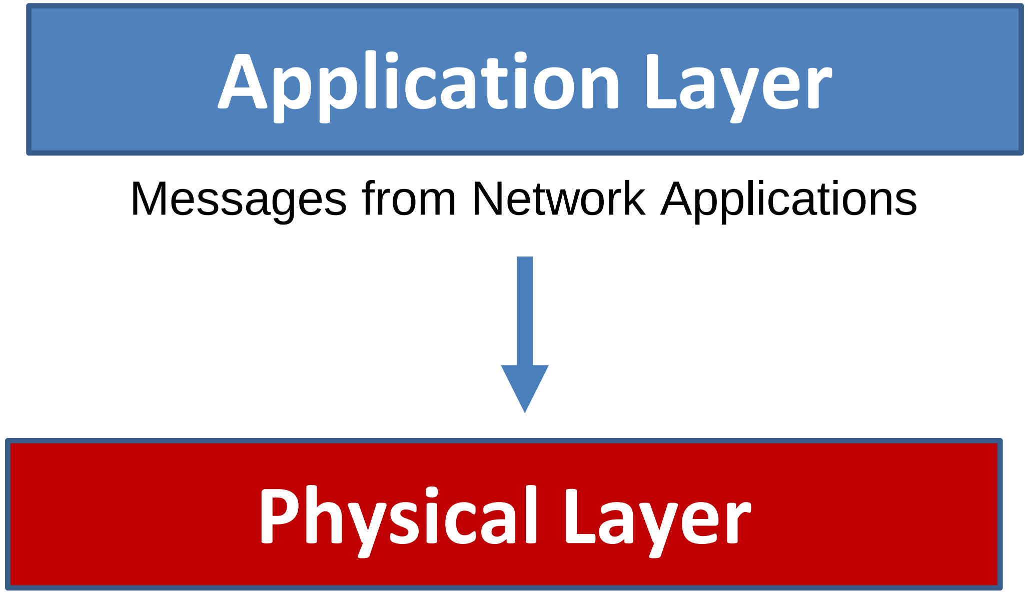
Session Layer *

Transport Layer

Network Layer

Data Link Layer

Physical Layer



Application Layer

Messages from Network Applications

Physical Layer

Bits being transmitted over a copper wire

In the textbook, they condense it to a 5-layer model, but 7 layers is what is most used

DNS

Humans browse the web using hostnames

- (They need English)

Computers understand numbers

- (They need IP addresses)

DNS

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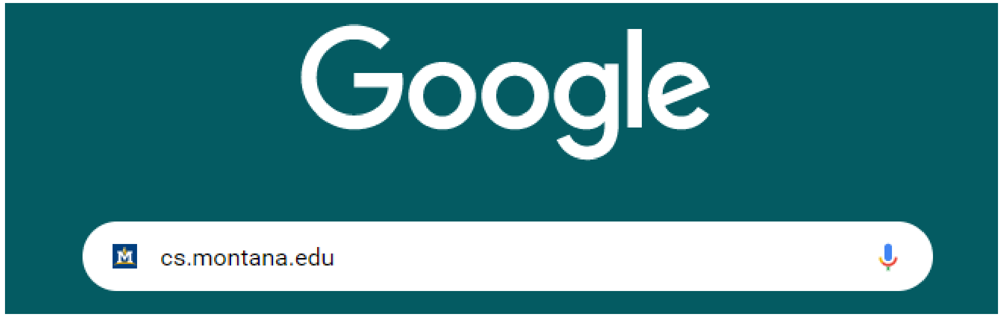

cs.montana.edu

???

153.90.127.197

DNS

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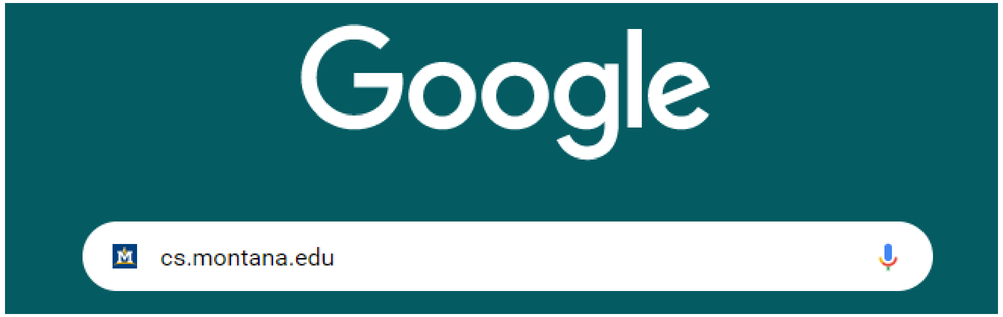
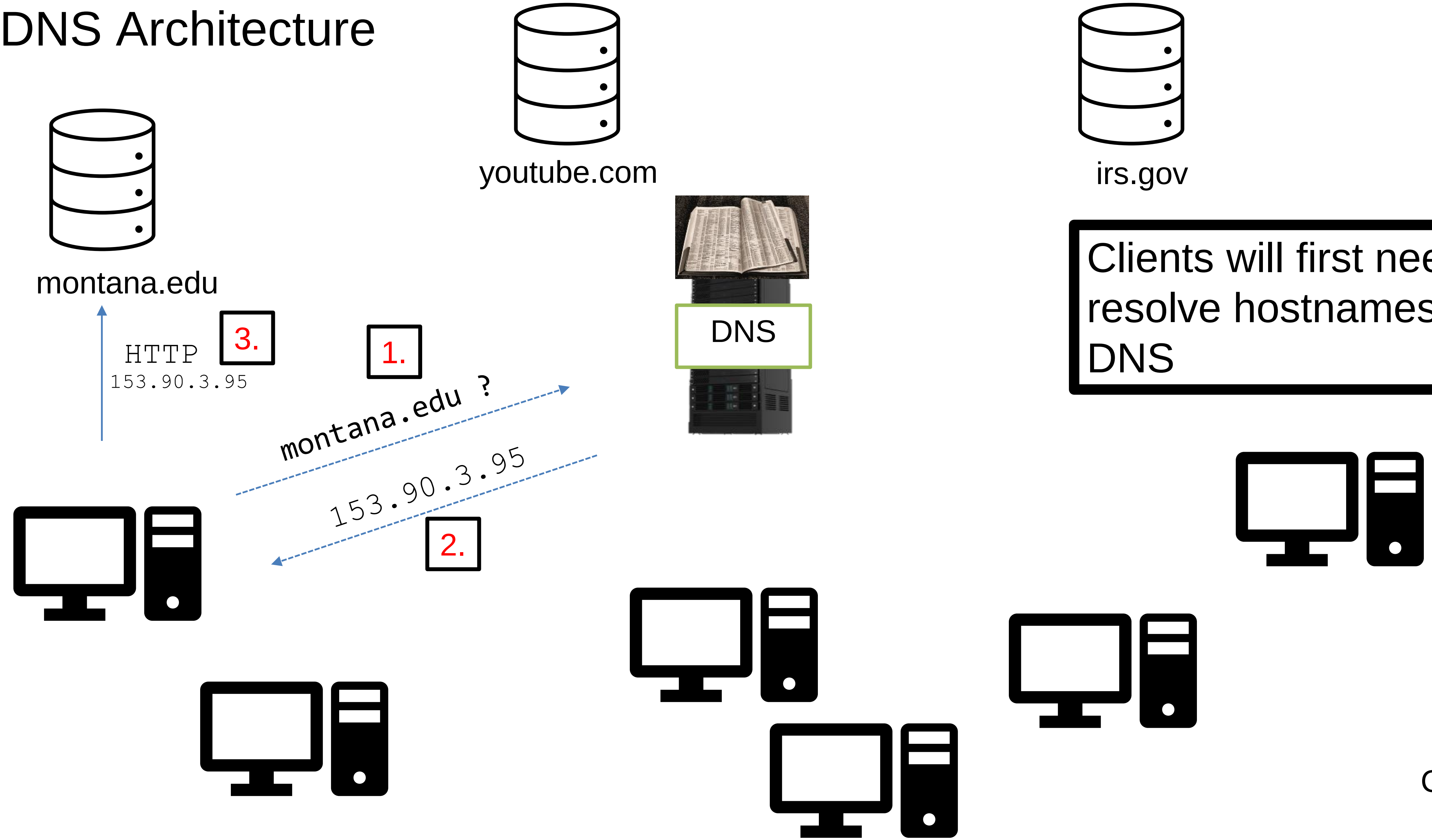


cs.montana.edu

→ **DNS** → 153.90.127.197

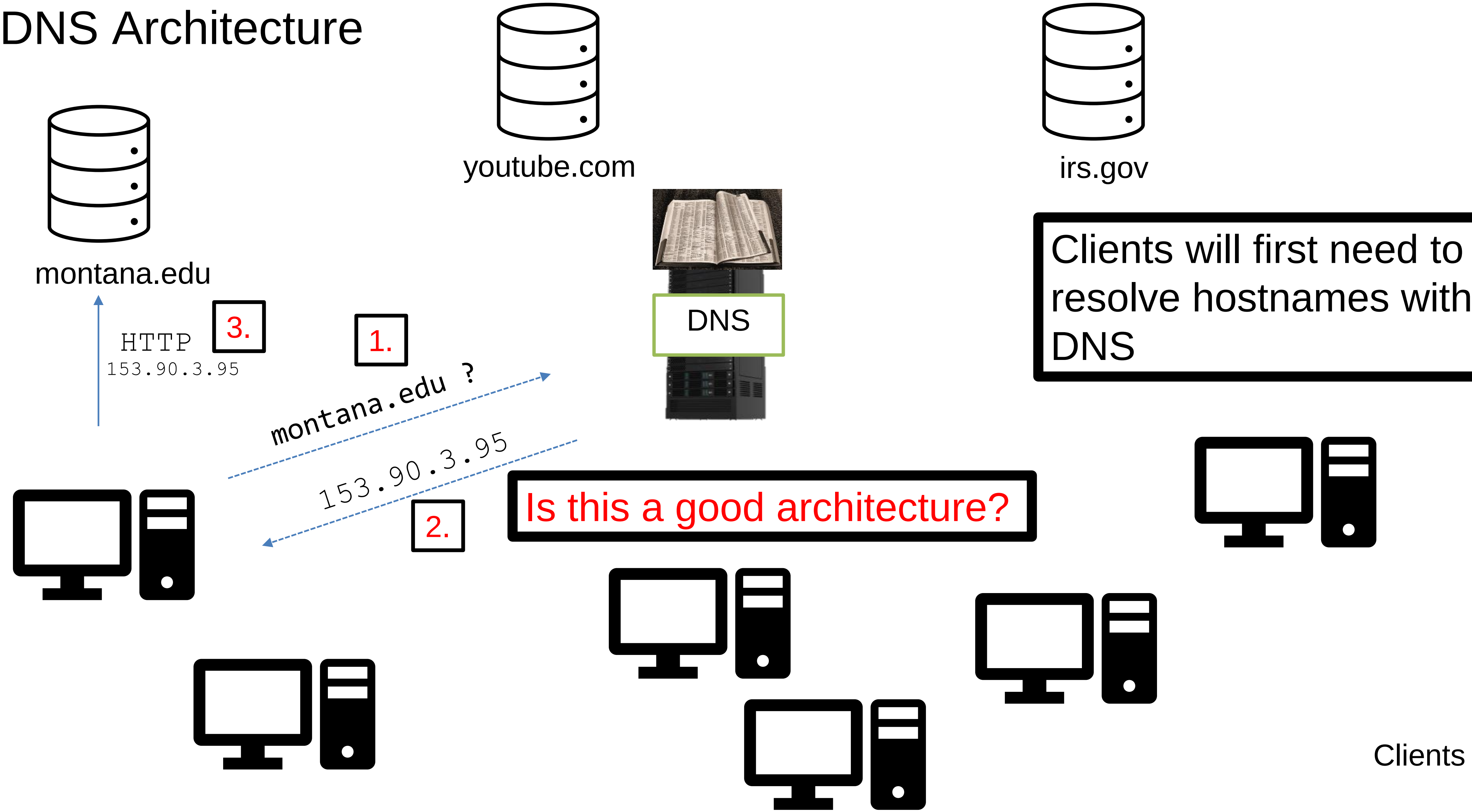
Domain Name System (DNS) is a database of mappings between hostnames and IP addresses

DNS Architecture



Clients will first need to resolve hostnames with DNS

DNS Architecture



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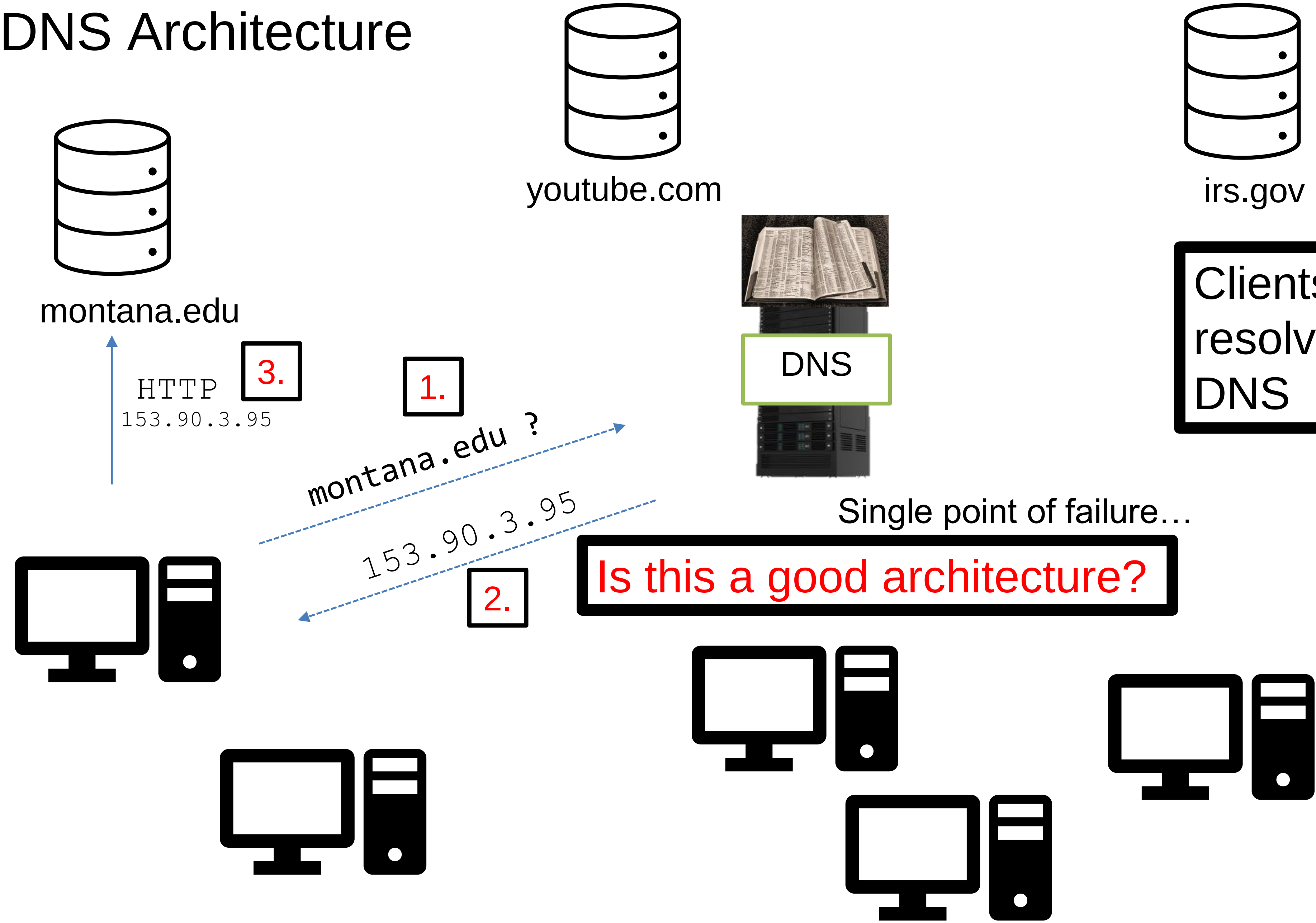
Is this a good architecture?

DNS Architecture

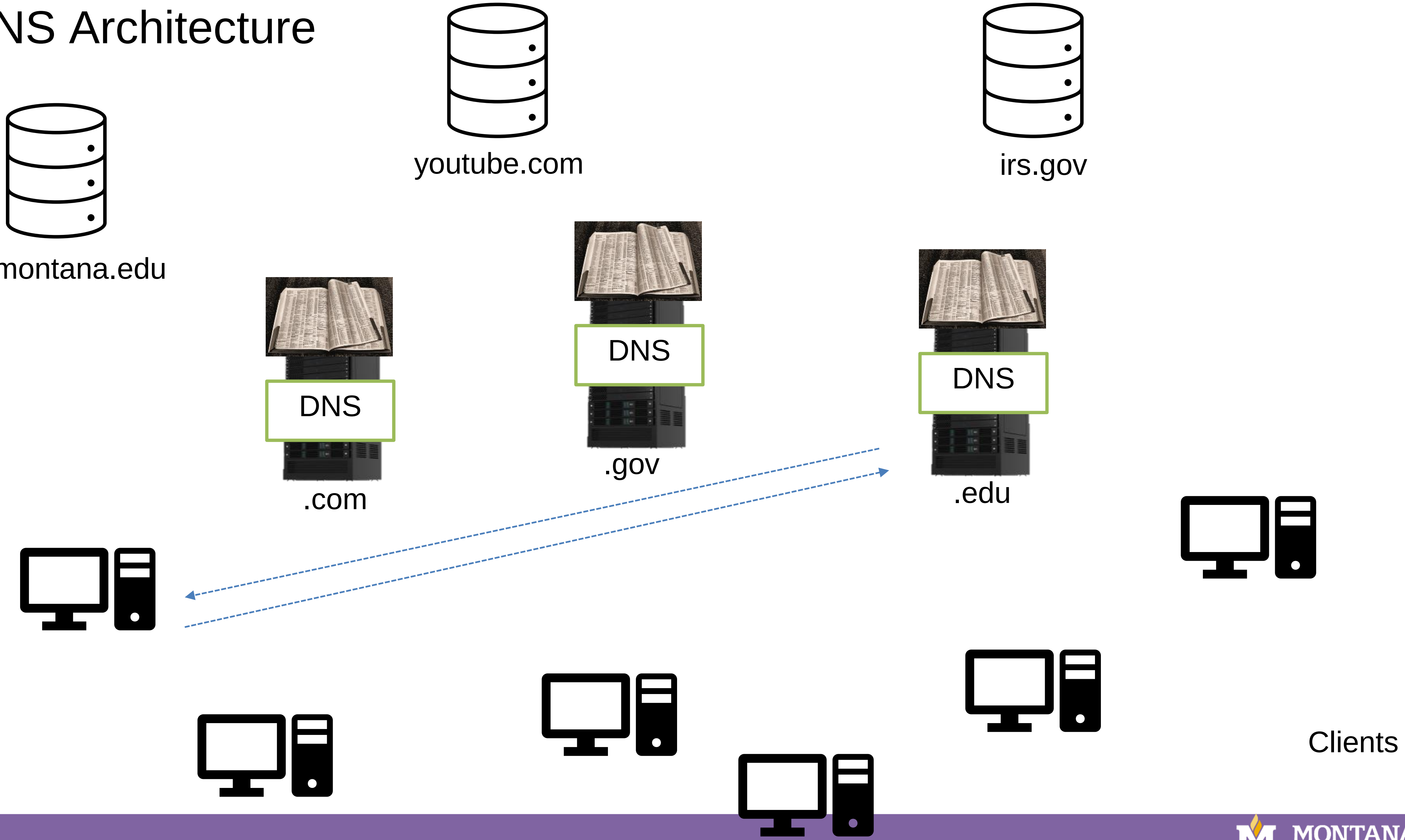


Clients will first need to resolve hostnames with DNS

Single point of failure…

Is this a good architecture?

DNS Architecture



DNS Architecture

(how big would that map be?)

- DNS is a **distributed**, **hierarchical** database (no DNS server has all the records!)

Hierarchy consists of different types of DNS servers:

DNS Architecture

- DNS is a **distributed**, **hierarchical** database (no DNS server has all the records!)

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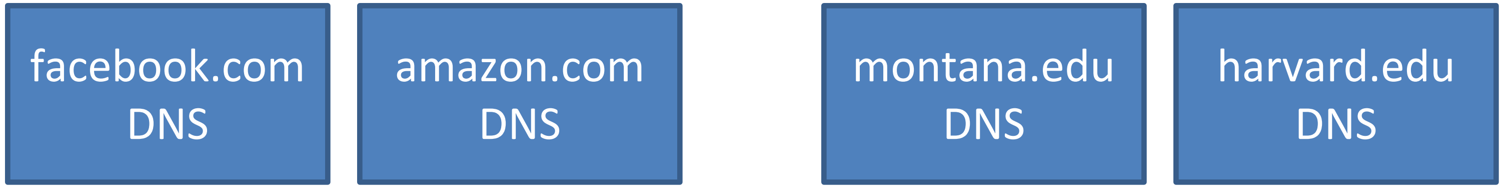
Authoritative DNS servers- Organization’s own DNS with up-to-date records



DNS Architecture

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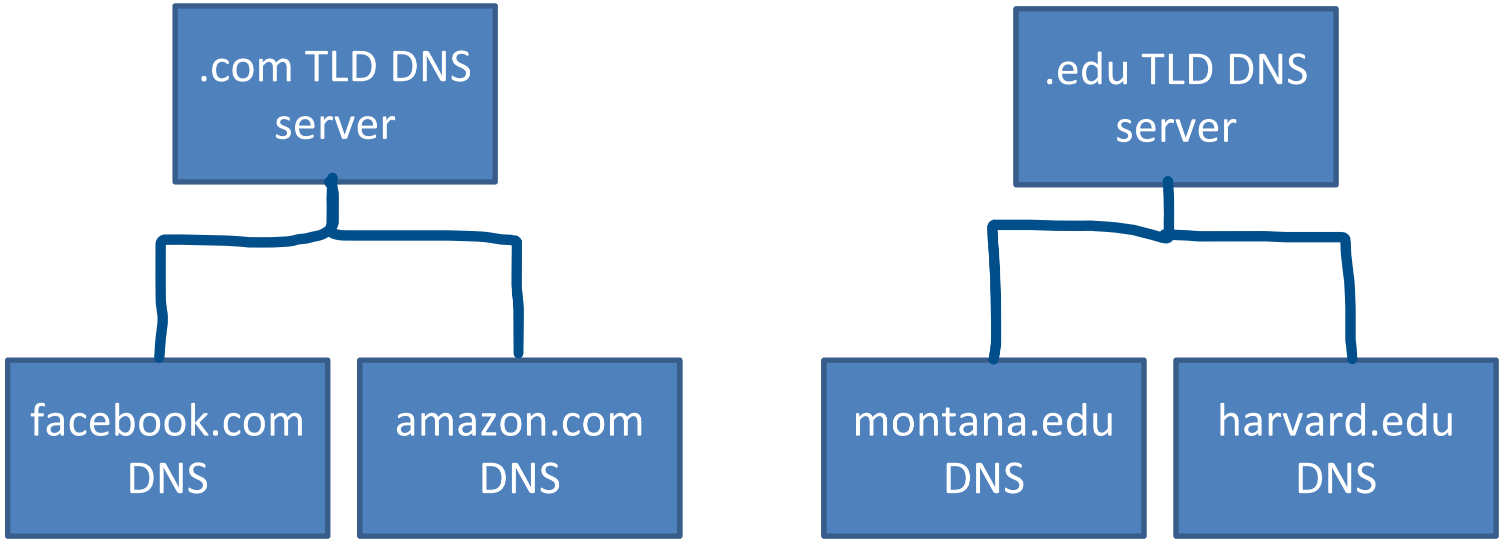
Top-level domain (TLD) servers- responsible for keeping IP addresses for authoritative DNS servers for each top-level domain (.com, .edu, .jp, etc)



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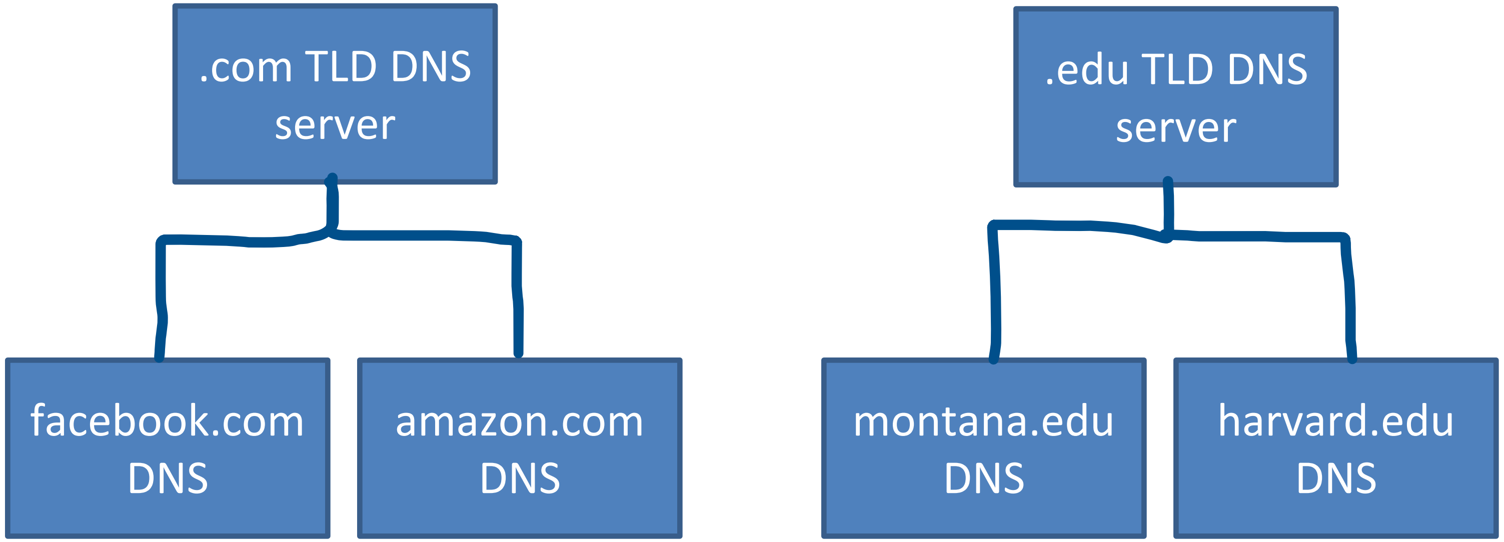

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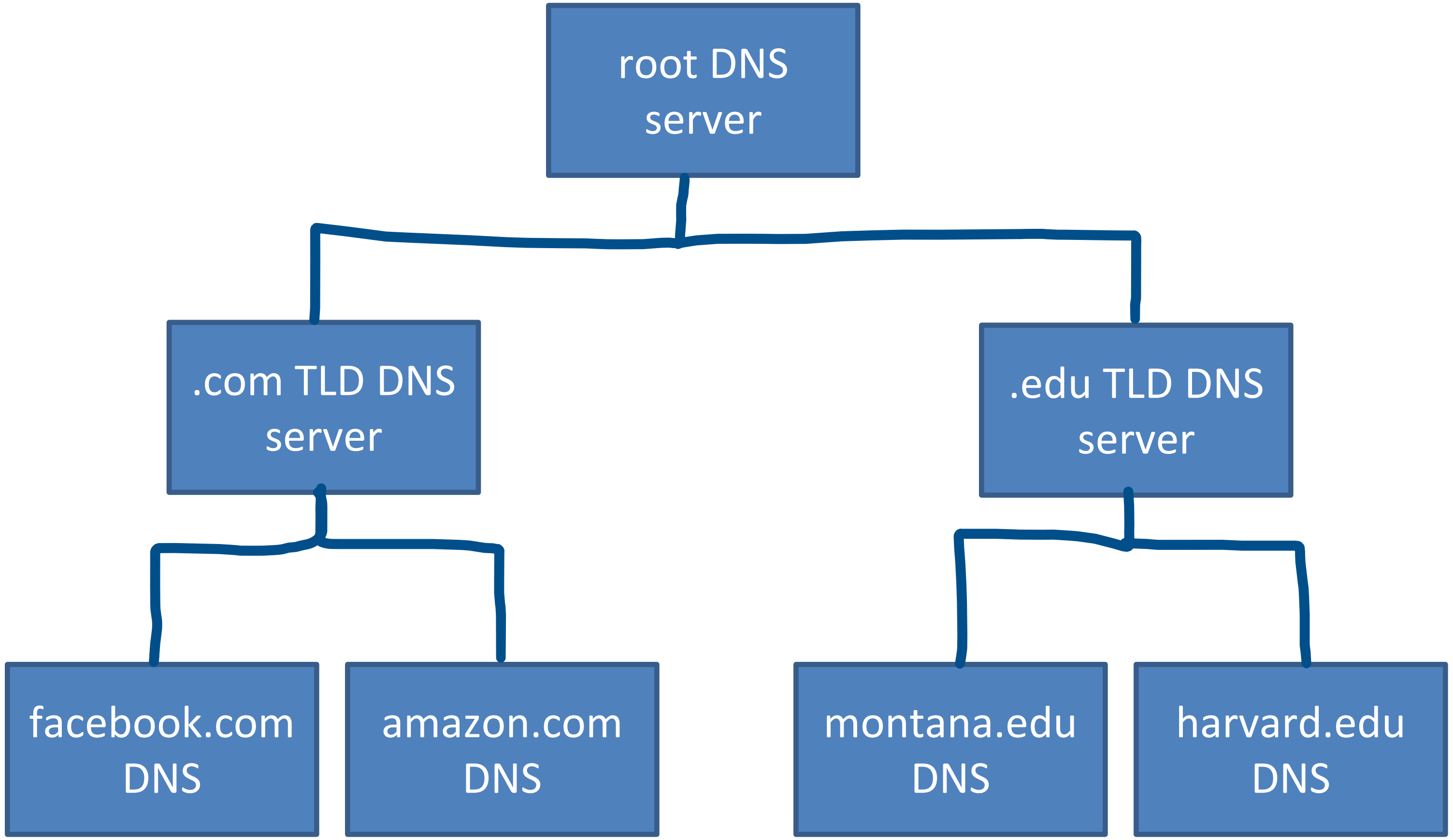
Root DNS servers- responsible for maintaining IP addresses for TLD servers



DNS Architecture

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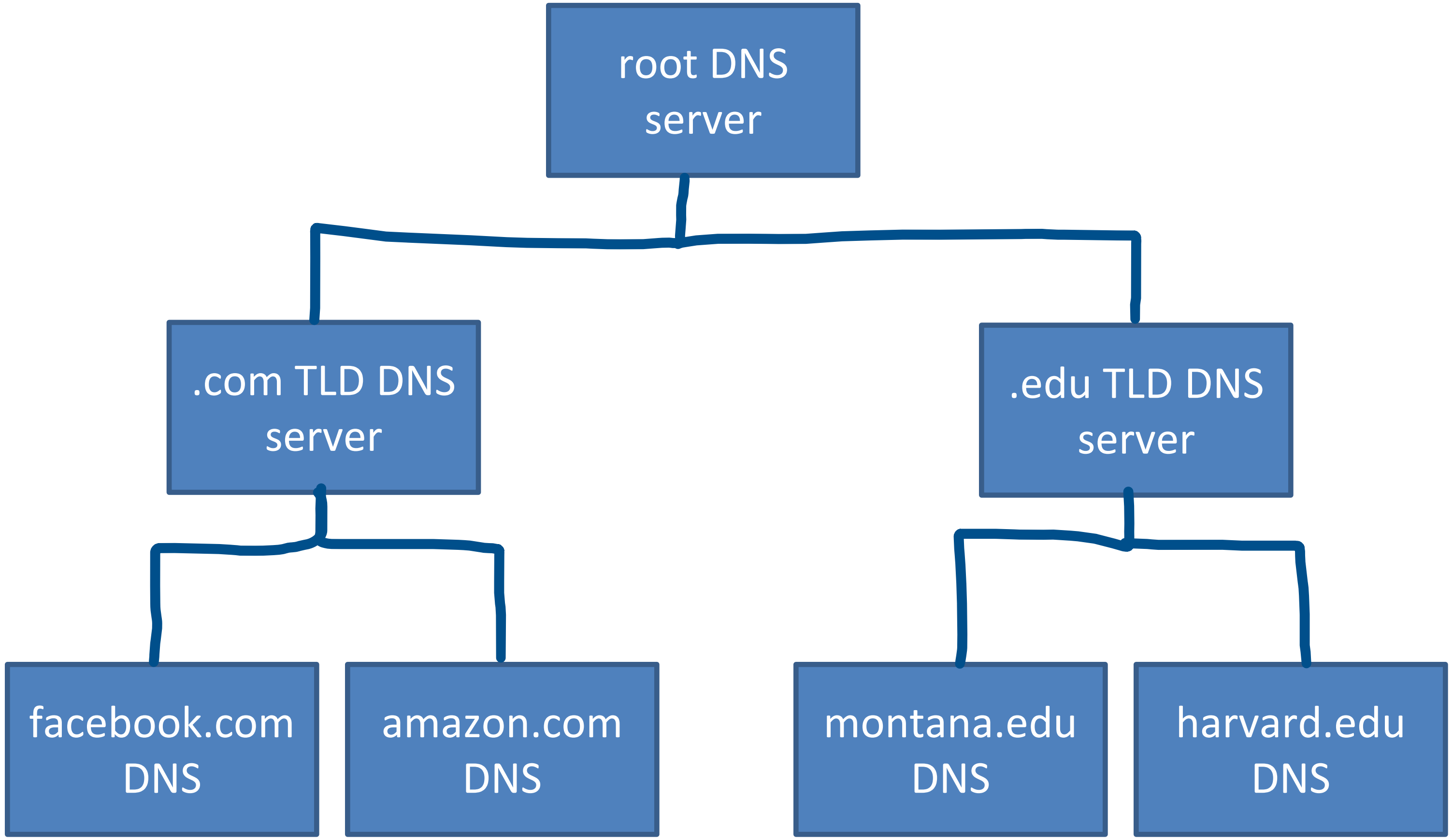
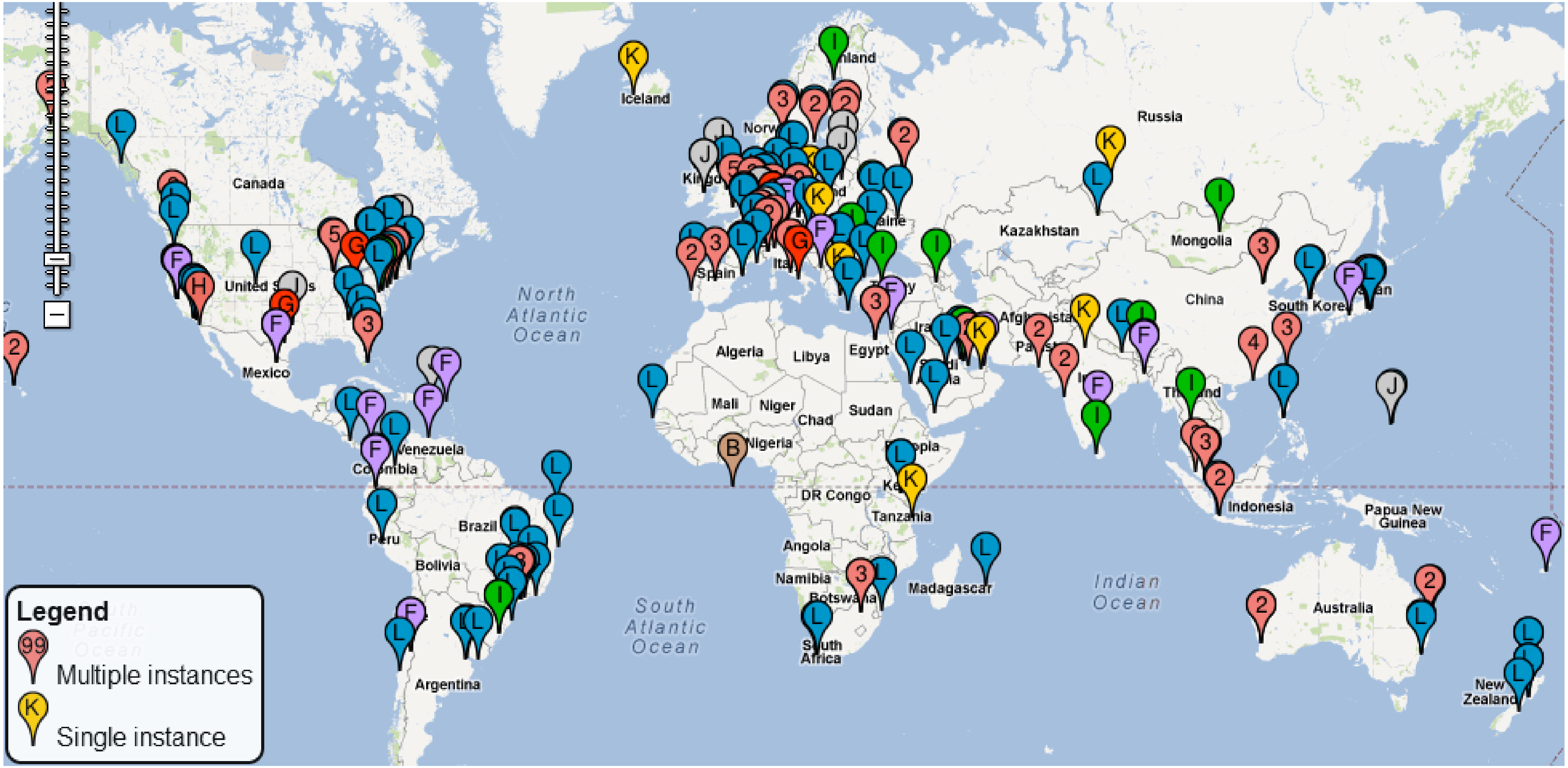


DNS Root server locations



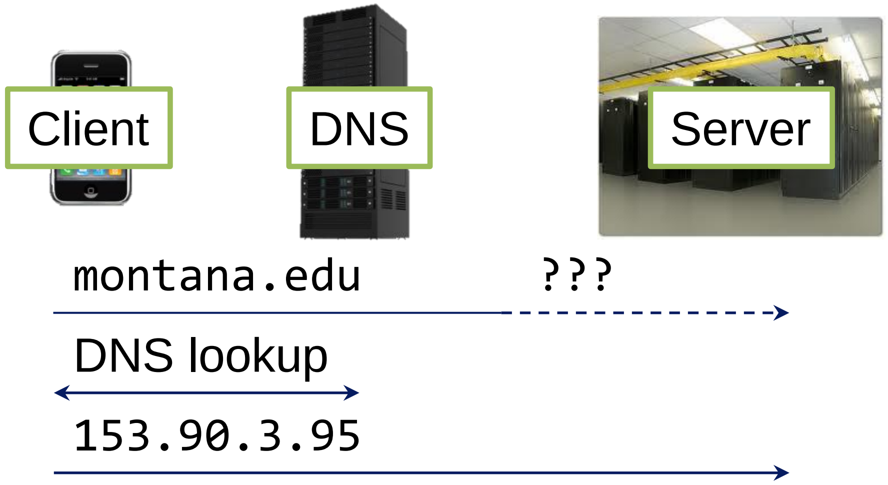
https://root-servers.org/

DNS

Application layer protocol

- Lookups over UDP on port 53

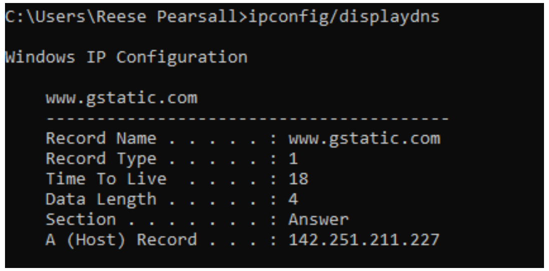
(handshake not needed)
(DNS requests are small)
(reliability can be added in the application layer)



DNS provides hostname to IP mappings, host aliasing, mail server aliasing, and load distribution

Local DNS servers are also used

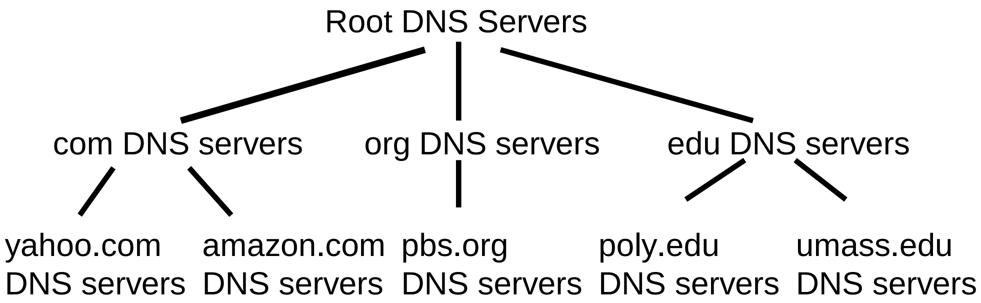
- Acts as a proxy
- Maintained by ISP
- Caches records



```
C:\Users\Reese Pearsall>ipconfig/displaydns

Windows IP Configuration

    www.gstatic.com
    ----------------------------------------
    Record Name . . . . . : www.gstatic.com
    Record Type . . . . . : 1
    Time To Live  . . . . : 18
    Data Length . . . . . : 4
    Section . . . . . . . : Answer
    A (Host) Record . . . : 142.251.211.227
```

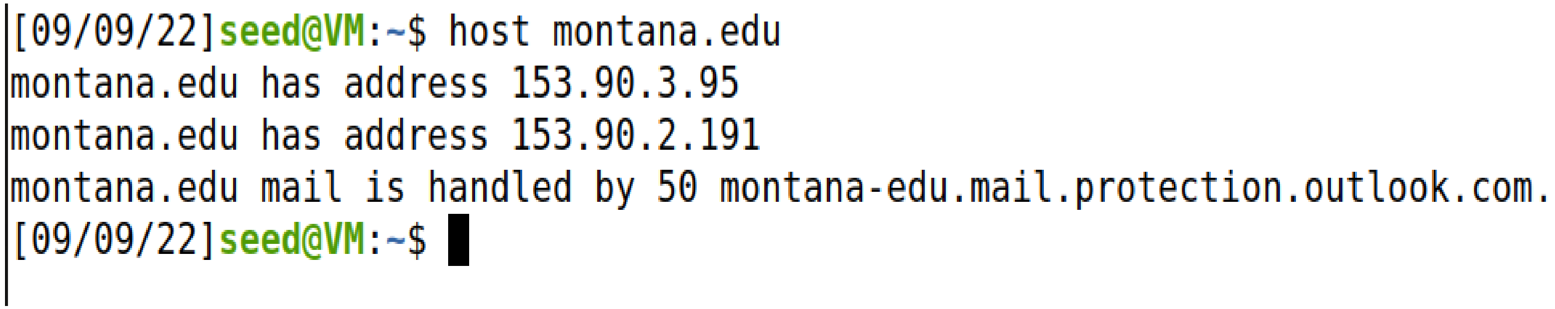


Some DNS records are also stored and maintained in your computer

- Any issues?? 👀

What if an IP address gets changed?

DNS Commands



```
[09/09/22]seed@VM:~$ host montana.edu
montana.edu has address 153.90.3.95
montana.edu has address 153.90.2.191
montana.edu mail is handled by 50 montana-edu.mail.protection.outlook.com.
[09/09/22]seed@VM:~$ 
```

- DNS services
  - Hostname to IP address translation

    `host montana.edu`
  - Hostname to IPv6 address translation
    - `host -t AAAA montana.edu`
  - Host aliasing

    `host -t CNAME img.huffingtonpost.com`
  - Mail server aliasing

    `host -t MX montana.edu`
  - Load distribution

    ```
    host huffpost.com | grep "address" | sed -n -e
    's/^.*address //p'
    ```
  - Redirection
    - Look up same host from servers in different regions

    `host google.com 8.8.8.8`

153.90.3.95

(`nslookup` also works. This is what you will use in the lab)

DNS Commands

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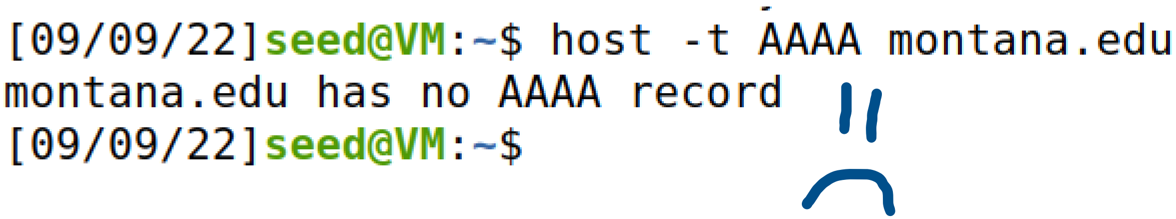

```
[09/09/22]seed@VM:~$ host -t AAAA montana.edu
montana.edu has no AAAA record
[09/09/22]seed@VM:~$
```

DNS Commands

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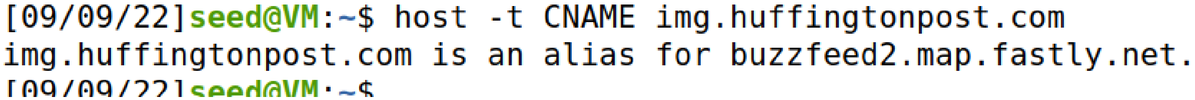

```
[09/09/22]seed@VM:~$ host -t CNAME img.huffingtonpost.com
img.huffingtonpost.com is an alias for buzzfeed2.map.fastly.net.
[09/09/22]seed@VM:~$
```

DNS Commands

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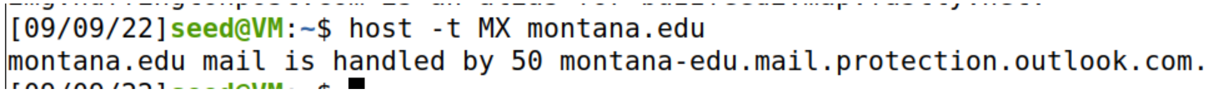

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  - Load distribution

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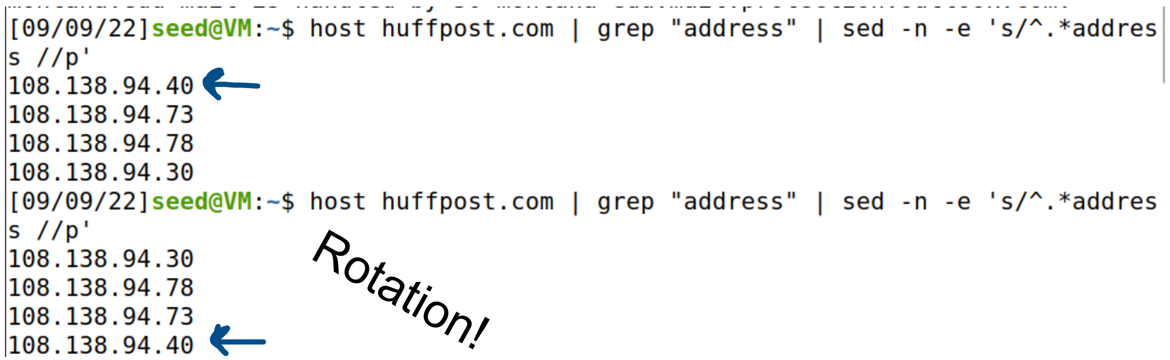

```
[09/09/22]seed@VM:~$ host huffpost.com | grep "address" | sed -n -e 's/^.*addres
s //p'
108.138.94.40
108.138.94.73
108.138.94.78
108.138.94.30
[09/09/22]seed@VM:~$ host huffpost.com | grep "address" | sed -n -e 's/^.*addres
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108.138.94.73
108.138.94.40
```

Rotation!

DNS Commands

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  - Hostname to IP address translation

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  - Hostname to IPv6 address translation
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    host google.com 8.8.8.8
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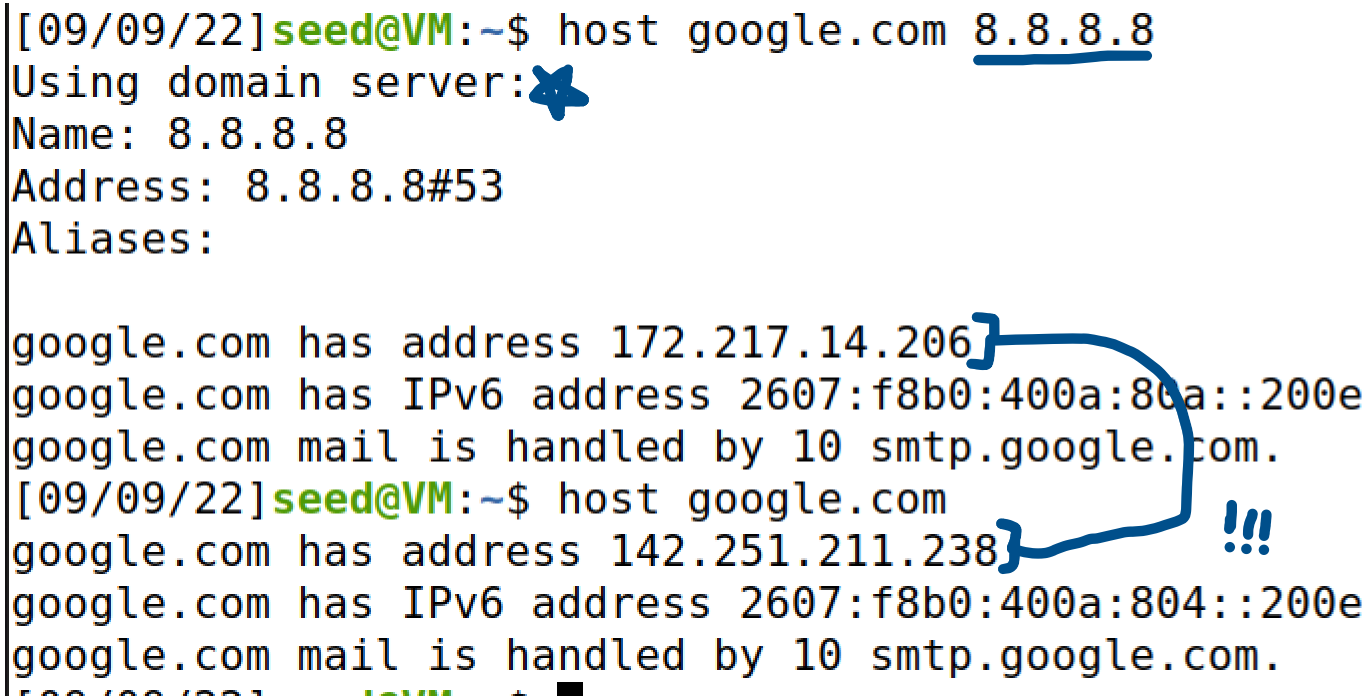

```
[09/09/22]seed@VM:~$ host google.com 8.8.8.8
Using domain server:
Name: 8.8.8.8
Address: 8.8.8.8#53
Aliases:

google.com has address 172.217.14.206
google.com has IPv6 address 2607:f8b0:400a:80a::200e
google.com mail is handled by 10 smtp.google.com.
[09/09/22]seed@VM:~$ host google.com
google.com has address 142.251.211.238
google.com has IPv6 address 2607:f8b0:400a:804::200e
google.com mail is handled by 10 smtp.google.com.
```

!!!

DNS Commands

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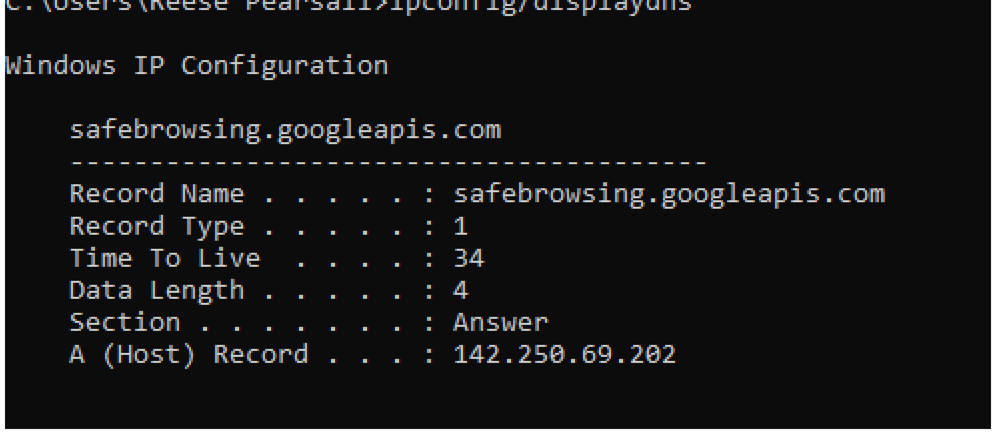
    host google.com 8.8.8.8
    ```

See cached DNS entries on computer

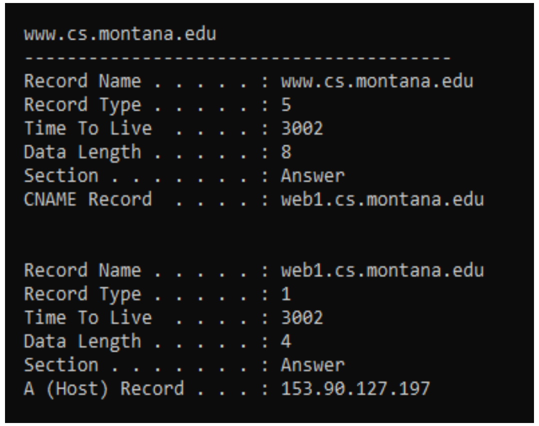
- `ipconfig/displaydns`



```
C:\Users\Reese Pearsall>ipconfig/displaydns

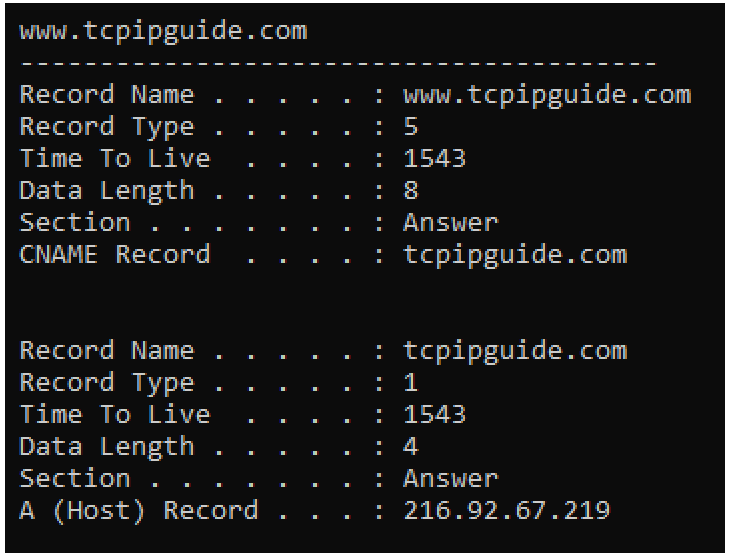
Windows IP Configuration

    safebrowsing.googleapis.com
    ----------------------------------------
    Record Name . . . . . : safebrowsing.googleapis.com
    Record Type . . . . . : 1
    Time To Live  . . . . : 34
    Data Length . . . . . : 4
    Section . . . . . . . : Answer
    A (Host) Record . . . : 142.250.69.202
```



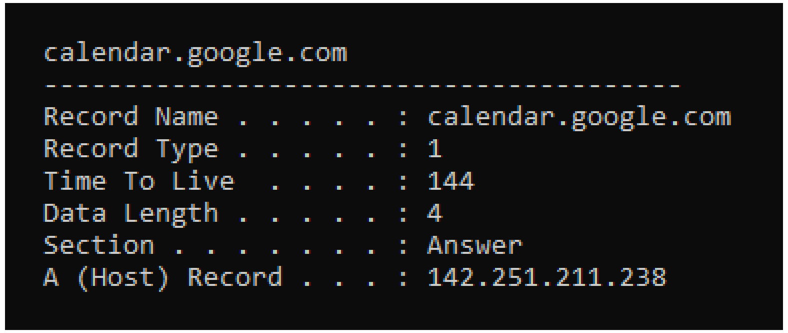
```
www.cs.montana.edu
----------------------------------------
Record Name . . . . . : www.cs.montana.edu
Record Type . . . . . : 5
Time To Live  . . . . : 3002
Data Length . . . . . : 8
Section . . . . . . . : Answer
CNAME Record  . . . . : web1.cs.montana.edu


Record Name . . . . . : web1.cs.montana.edu
Record Type . . . . . : 1
Time To Live  . . . . : 3002
Data Length . . . . . : 4
Section . . . . . . . : Answer
A (Host) Record . . . : 153.90.127.197
```



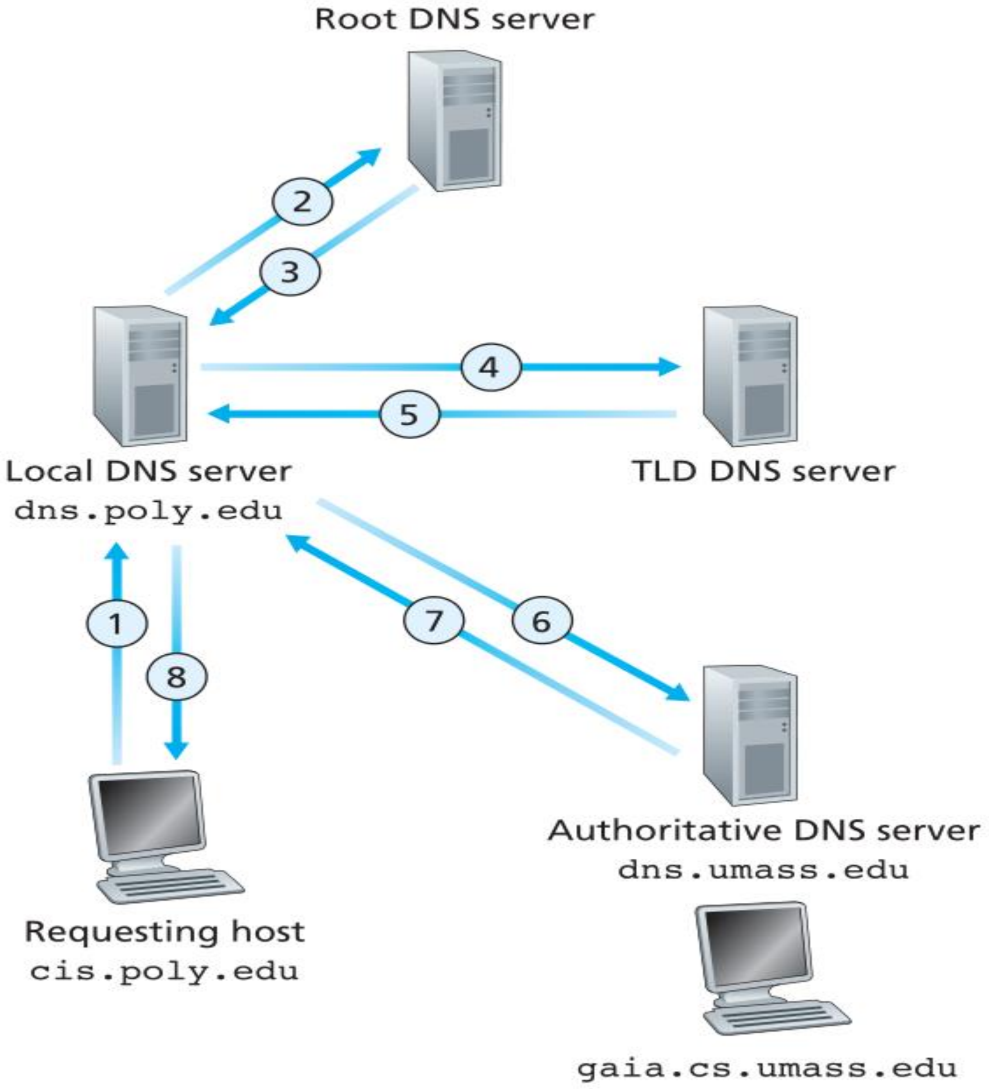
```
www.tcpipguide.com
----------------------------------------
Record Name . . . . . : www.tcpipguide.com
Record Type . . . . . : 5
Time To Live  . . . . : 1543
Data Length . . . . . : 8
Section . . . . . . . : Answer
CNAME Record  . . . . : tcpipguide.com


Record Name . . . . . : tcpipguide.com
Record Type . . . . . : 1
Time To Live  . . . . : 1543
Data Length . . . . . : 4
Section . . . . . . . : Answer
A (Host) Record . . . : 216.92.67.219
```

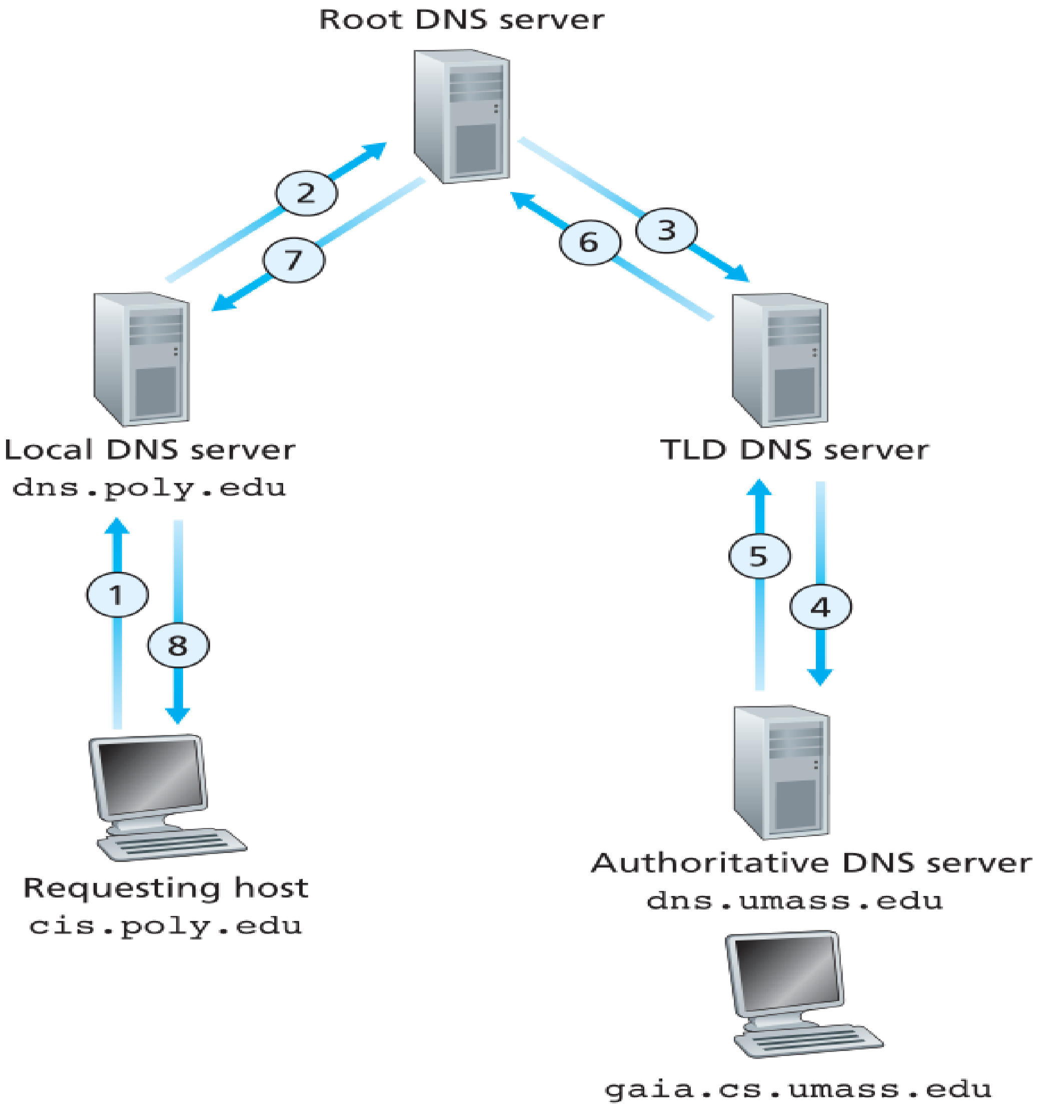


```
calendar.google.com
----------------------------------------
Record Name . . . . . : calendar.google.com
Record Type . . . . . : 1
Time To Live  . . . . : 144
Data Length . . . . . : 4
Section . . . . . . . : Answer
A (Host) Record . . . : 142.251.211.238
```

DNS Requests



Iterative Lookup



Recursive Lookup

DNS Response Records

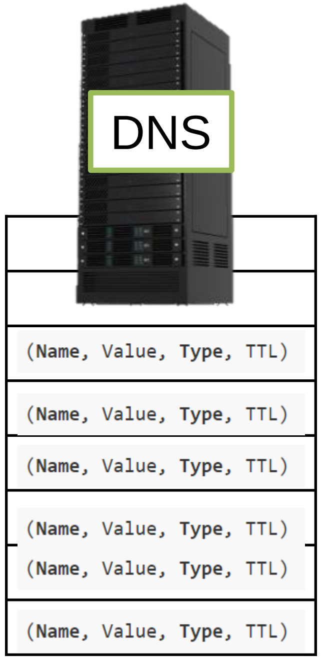
```
(Name, Value, Type, TTL)
(Name, Value, Type, TTL)
(Name, Value, Type, TTL)
(Name, Value, Type, TTL)
(Name, Value, Type, TTL)
(Name, Value, Type, TTL)
```

DNS servers store **resource records (RRs)**

RR is a four-tuple

```
(Name, Value, Type, TTL)
```

DNS Response Records



(Name, Value, Type, TTL)
(Name, Value, Type, TTL)
(Name, Value, Type, TTL)
(Name, Value, Type, TTL) (Name, Value, Type, TTL)
(Name, Value, Type, TTL)

DNS servers store **resource records (RRs)**

RR is a four-tuple

```
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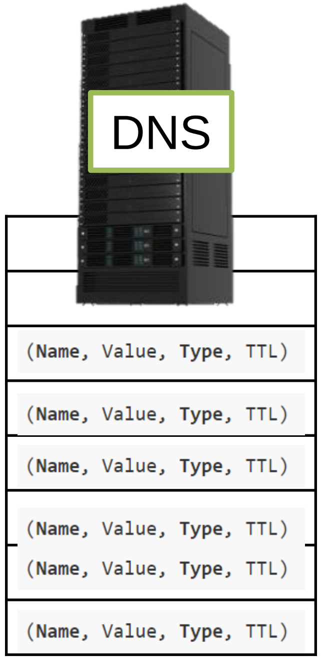
```

TTL – “Time to Live”. Determines when a resource should be removed from a cache

DNS Response Records



(Name, Value, Type, TTL)

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(Name, Value, Type, TTL)

DNS servers store **resource records (RRs)**

RR is a four-tuple

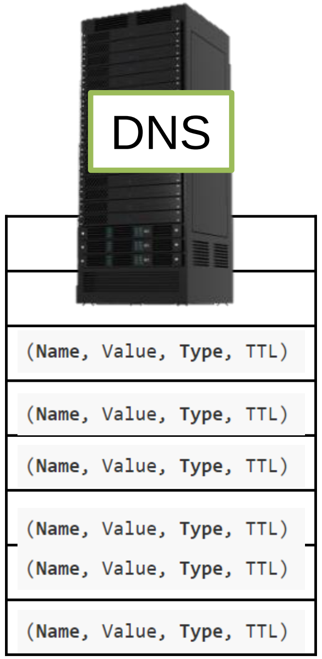
```
(Name, Value, Type, TTL)
```

TTL – “Time to Live”. Determines when a resource should be removed from a cache

Type – type of record

- Type **A** – IPv4 address
- Type **AAAA** – IPv6 address
- Type **NS** – Authoritative DNS hostname
  (`foo.com`, `dns.foo.com`)
- Type **CNAME** – Canonical hostname for an alias
  (`foo.com`, `items.foo.com`)
- Type **MX-** Canonical name for a mail server
  (`foo.com`, `mail.foo.com`)

DNS Response Records



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(Name, Value, Type, TTL)

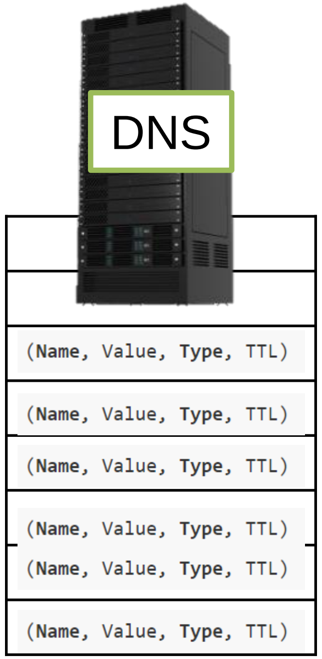
DNS servers store **resource records (RRs)**

RR is a four-tuple

```
(Name, Value, Type, TTL)
```

```
(foo.com, 145.37.93.126, A, 24)
(foo.com, 0913:cc84:9414:59e6:ae63:7299:dae5:b2f9, AAAA, 24)
(foo.com, mail.foo.com, MX, 24)
(foo.com, dns.foo.com, NS, 24)
(foo.com, items.foo.com, CNAME, 24)
```

DNS Response Records



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DNS servers store **resource records (RRs)**

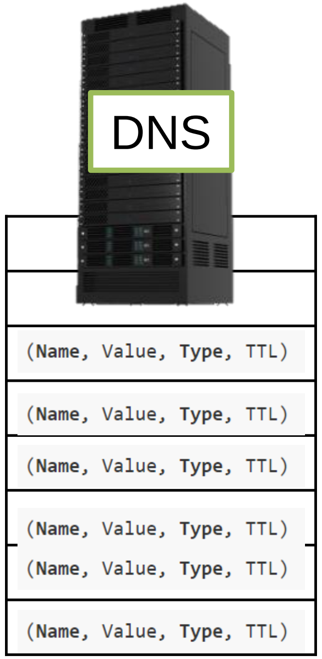
RR is a four-tuple

```
(Name, Value, Type, TTL)
```

```
(foo.com, 145.37.93.126, A, 24)
(foo.com, 0913:cc84:9414:59e6:ae63:7299:dae5:b2f9, AAAA, 24)
(foo.com, mail.foo.com, MX, 24)
(foo.com, dns.foo.com, NS, 24)
(foo.com, items.foo.com, CNAME, 24)
```

If a nameserver is authoritative for a particular domain, it will have type A record(s) for the hostname

DNS Response Records



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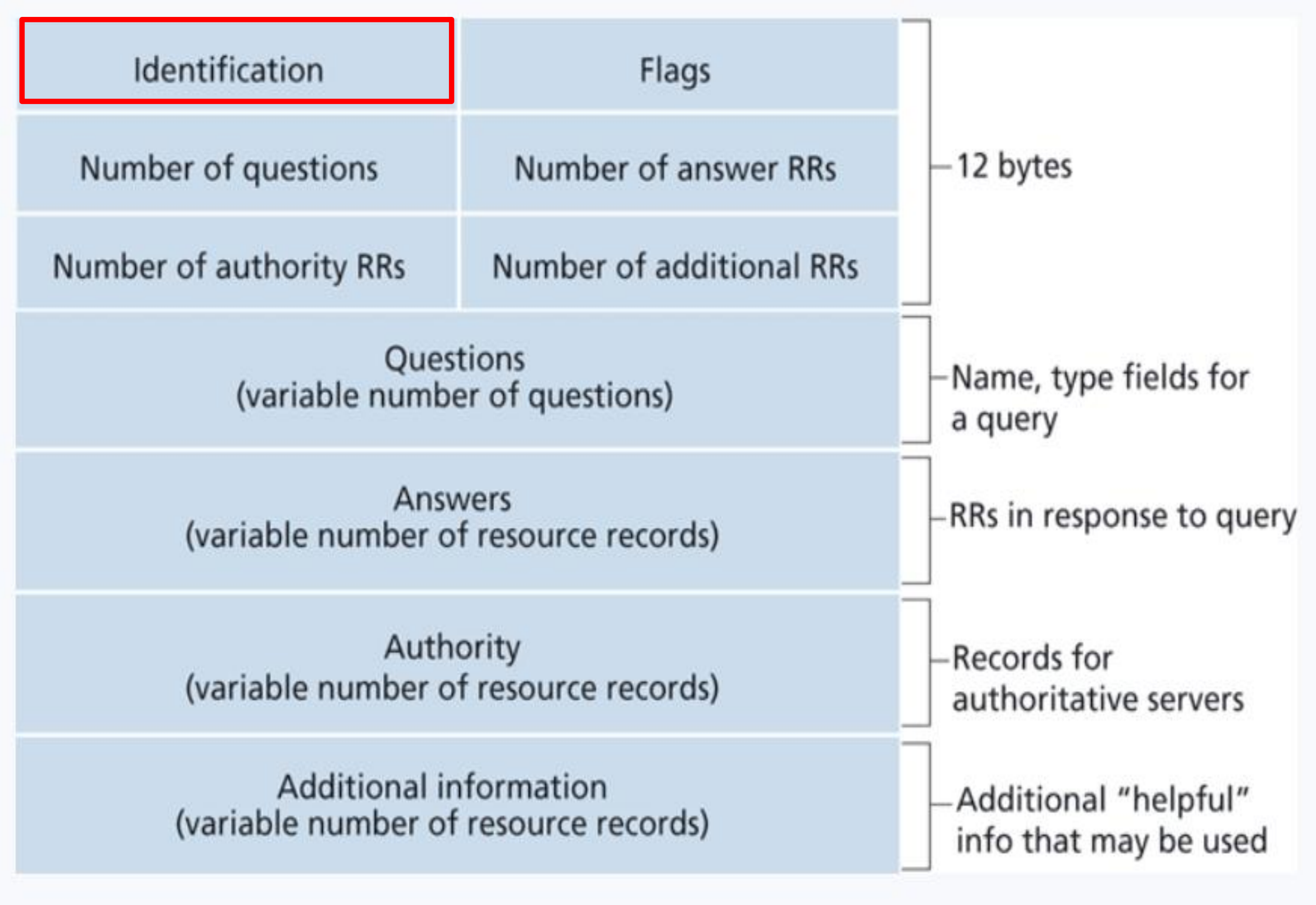
If a nameserver is authoritative for a particular domain, it will have type A record(s) for the hostname

Otherwise, it will have NS records for the DNS server that does know the answer

DNS Requests *(The format of a DNS request packet)*



Identification

Flags

Number of questions

Number of answer RRs

Number of authority RRs

Number of additional RRs

12 bytes

Questions (variable number of questions)

Name, type fields for a query

Answers (variable number of resource records)

RRs in response to query

Authority (variable number of resource records)

Records for authoritative servers

Additional information (variable number of resource records)

Additional "helpful" info that may be used

ID number for the query. Used to match a request to its response easily

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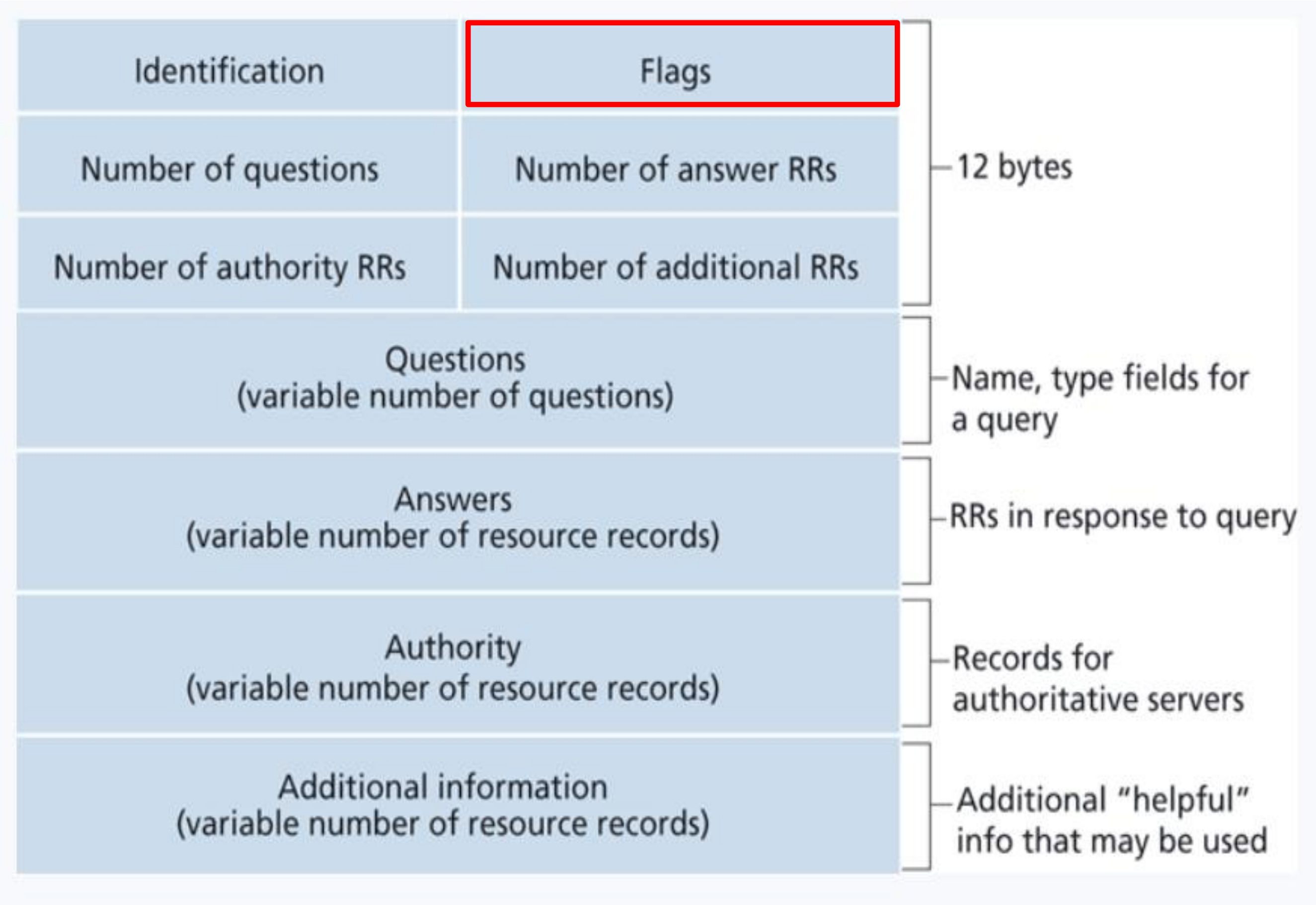

Identification	Flags	12 bytes
Number of questions	Number of answer RRs	
Number of authority RRs	Number of additional RRs	
Questions (variable number of questions)		Name, type fields for a query
Answers (variable number of resource records)		RRs in response to query
Authority (variable number of resource records)		Records for authoritative servers
Additional information (variable number of resource records)		Additional "helpful" info that may be used

ID number for the query. Used to match a request to its response easily

A set of 0/1 that provide information about the query

- Is it authoritative?
- Is it a response or a query?
- Should it be done recursively?

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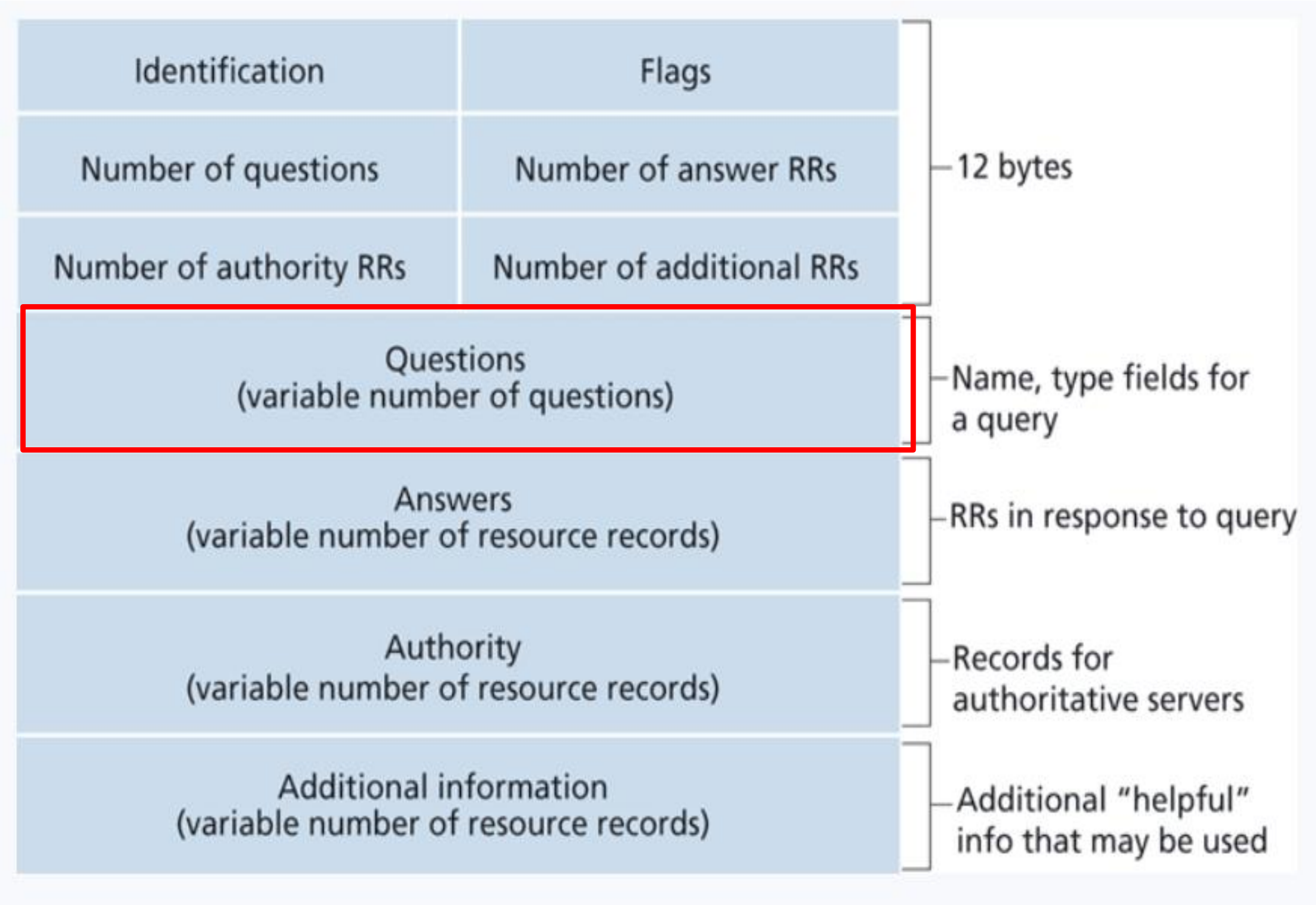

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Questions
(variable number of questions)

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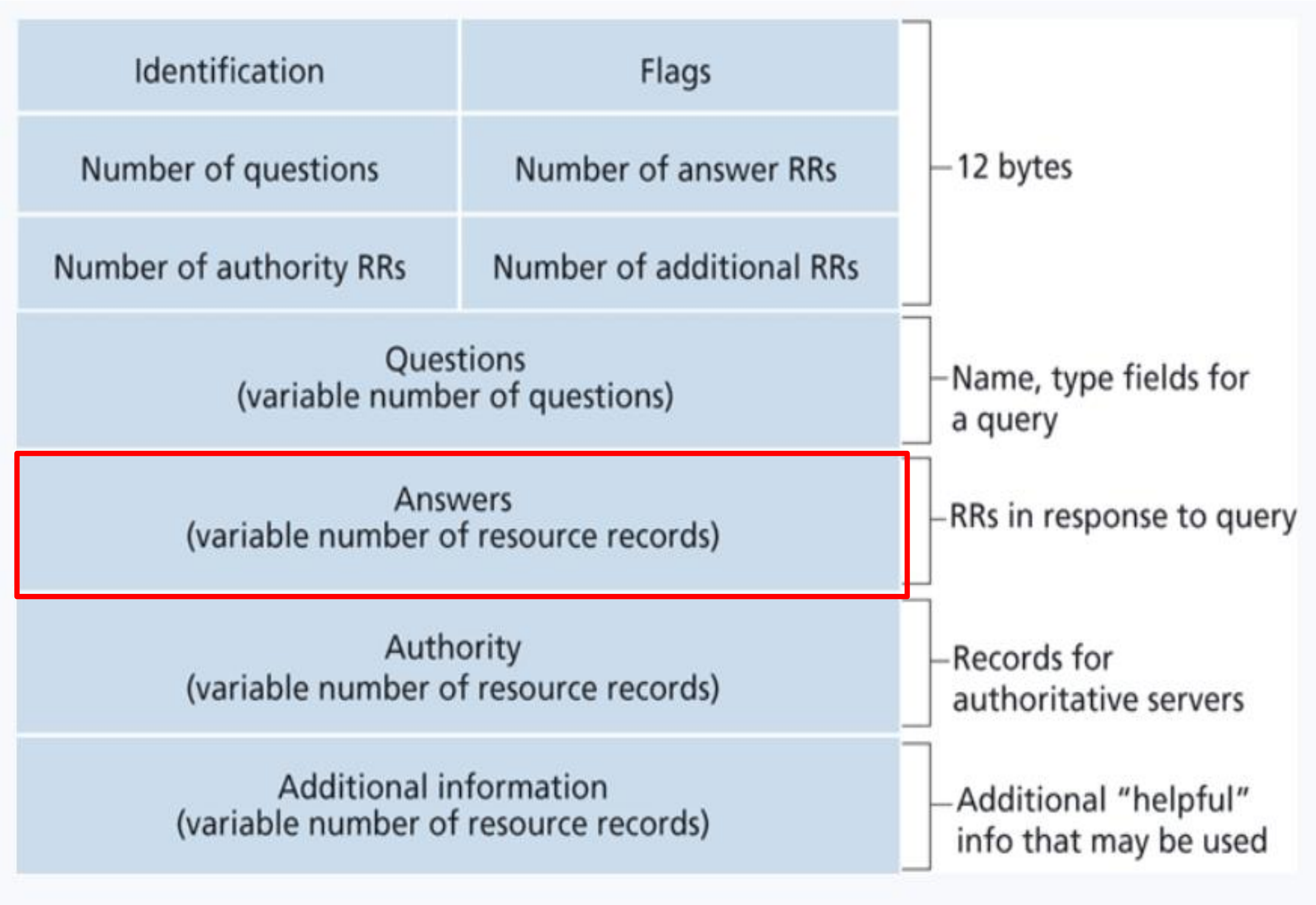

Identification	Flags
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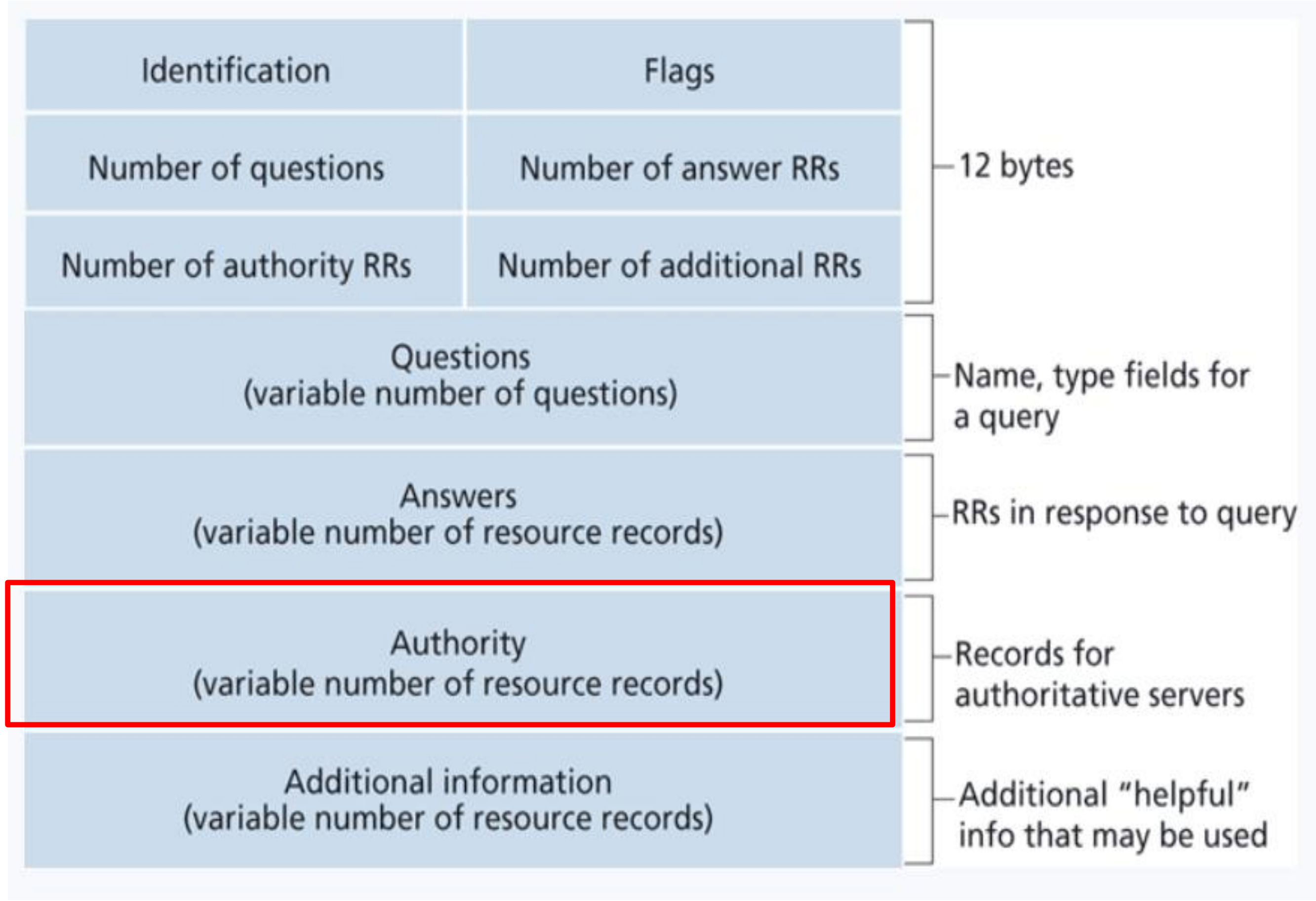

Identification	Flags
Number of questions	Number of answer RRs
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12 bytes

Questions (variable number of questions) — Name, type fields for a query

Answers (variable number of resource records) — RRs in response to query

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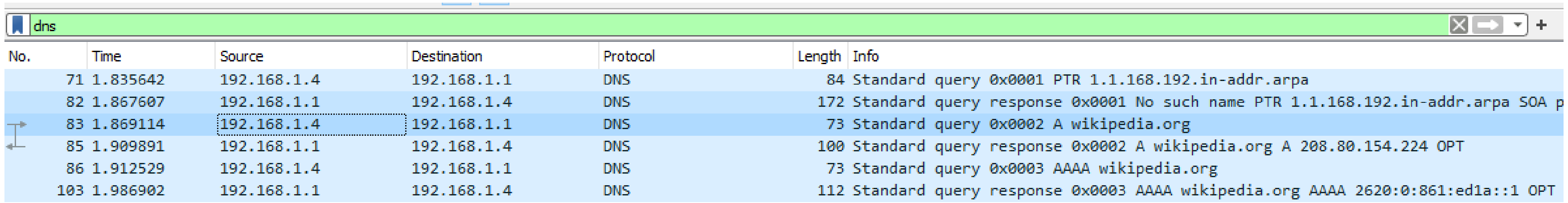
Information about other authoritative server

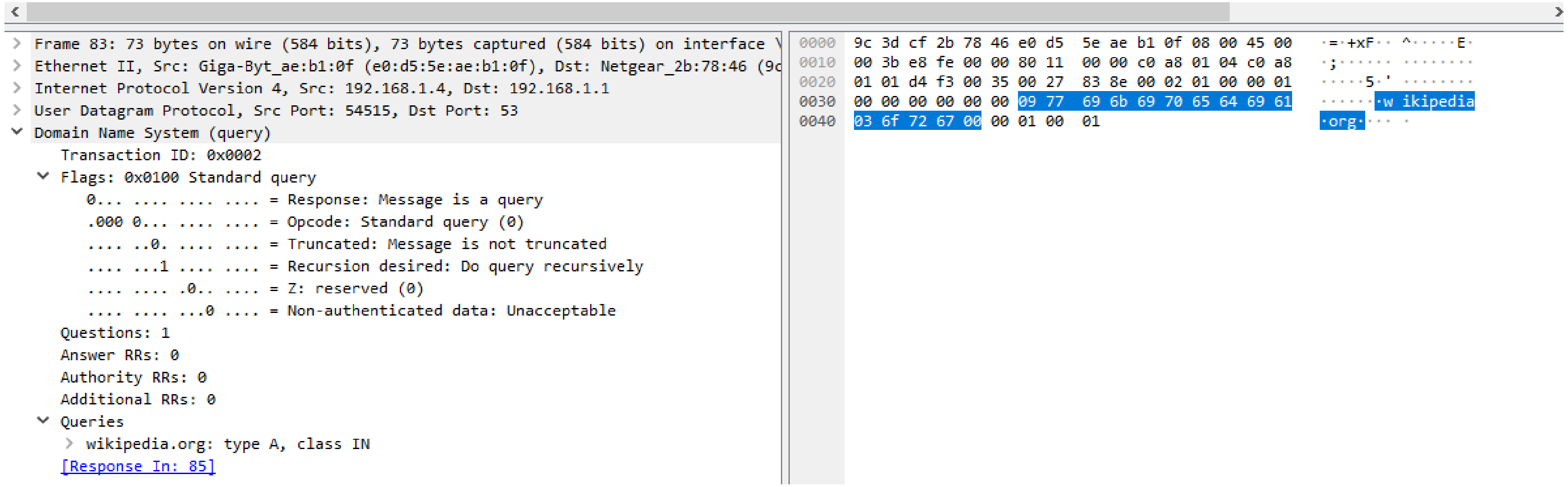
DNS Requests in Wireshark



```
dns

No.     Time       Source        Destination   Protocol  Length Info
     71 1.835642   192.168.1.4   192.168.1.1   DNS           84 Standard query 0x0001 PTR 1.1.168.192.in-addr.arpa
     82 1.867607   192.168.1.1   192.168.1.4   DNS          172 Standard query response 0x0001 No such name PTR 1.1.168.192.in-addr.arpa SOA p
     83 1.869114   192.168.1.4   192.168.1.1   DNS           73 Standard query 0x0002 A wikipedia.org
     85 1.909891   192.168.1.1   192.168.1.4   DNS          100 Standard query response 0x0002 A wikipedia.org A 208.80.154.224 OPT
     86 1.912529   192.168.1.4   192.168.1.1   DNS           73 Standard query 0x0003 AAAA wikipedia.org
    103 1.986902   192.168.1.1   192.168.1.4   DNS          112 Standard query response 0x0003 AAAA wikipedia.org AAAA 2620:0:861:ed1a::1 OPT
```

```
nslookup wikipedia.org
```



```
> Frame 83: 73 bytes on wire (584 bits), 73 bytes captured (584 bits) on interface \
> Ethernet II, Src: Giga-Byt_ae:b1:0f (e0:d5:5e:ae:b1:0f), Dst: Netgear_2b:78:46 (9c
> Internet Protocol Version 4, Src: 192.168.1.4, Dst: 192.168.1.1
> User Datagram Protocol, Src Port: 54515, Dst Port: 53
v Domain Name System (query)
    Transaction ID: 0x0002
  v Flags: 0x0100 Standard query
      0... .... .... .... = Response: Message is a query
      .000 0... .... .... = Opcode: Standard query (0)
      .... ..0. .... .... = Truncated: Message is not truncated
      .... ...1 .... .... = Recursion desired: Do query recursively
      .... .... .0.. .... = Z: reserved (0)
      .... .... ...0 .... = Non-authenticated data: Unacceptable
    Questions: 1
    Answer RRs: 0
    Authority RRs: 0
    Additional RRs: 0
  v Queries
    > wikipedia.org: type A, class IN
    [Response In: 85]
```

```
0000  9c 3d cf 2b 78 46 e0 d5  5e ae b1 0f 08 00 45 00   ·=·+xF·· ^·····E·
0010  00 3b e8 fe 00 00 80 11  00 00 c0 a8 01 04 c0 a8   ·;······ ········
0020  01 01 d4 f3 00 35 00 27  83 8e 00 02 01 00 00 01   ·····5·' ········
0030  00 00 00 00 00 00 09 77  69 6b 69 70 65 64 69 61   ·······w ikipedia
0040  03 6f 72 67 00 00 01 00  01                        ·org···· ·
```