COMPUTER NETWORKS

TEAM NETWORKS

Department of Computer Science and Engineering

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COMPUTER NETWORKS

Application Layer

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Unit – 2 Application Layer

2.3 The Domain Name System

DNS: Domain Name System

people: many identifiers:

- SSN, name, passport #

Internet hosts, routers:

- IP address (32 bit) - used for addressing datagrams
- "name", e.g., cs.umass.edu - used by humans

Q: how to map between IP address and name, and vice versa ?

Domain Name System:

- *distributed database* implemented in hierarchy of many *name servers*
- *application-layer protocol:* hosts, name servers communicate to *resolve* names (address/name translation)
  - note: core Internet function, *implemented as application-layer protocol*
  - complexity at network's "edge"

www.abc.example.com -> Canonical Host Name
www.example.com -> Alias Name

DNS services

- hostname to IP address translation
- host aliasing
  - canonical, alias names
- mail server aliasing
- load distribution
  - replicated Web servers: many IP addresses correspond to one name

Q: Why not centralize DNS?

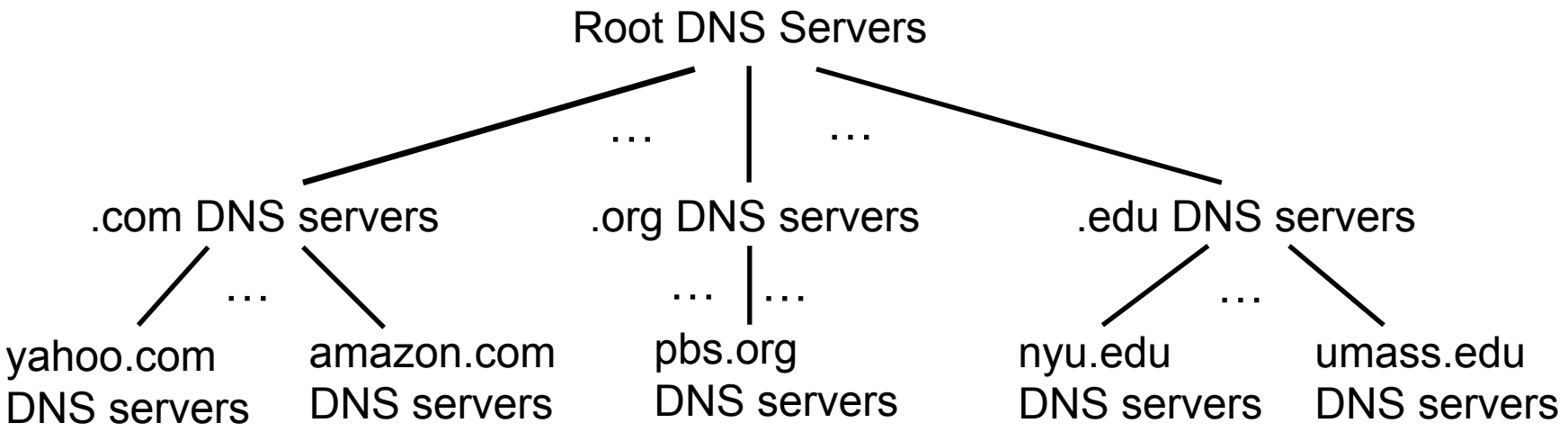
- single point of failure
- traffic volume
- distant centralized database
- maintenance

A: doesn't scale!

- Comcast DNS servers alone: 600B DNS queries per day

www.abc.example.com -> Canonical Host Name
bob@example.com -> Alias Name

DNS: a distributed, hierarchical database



Root

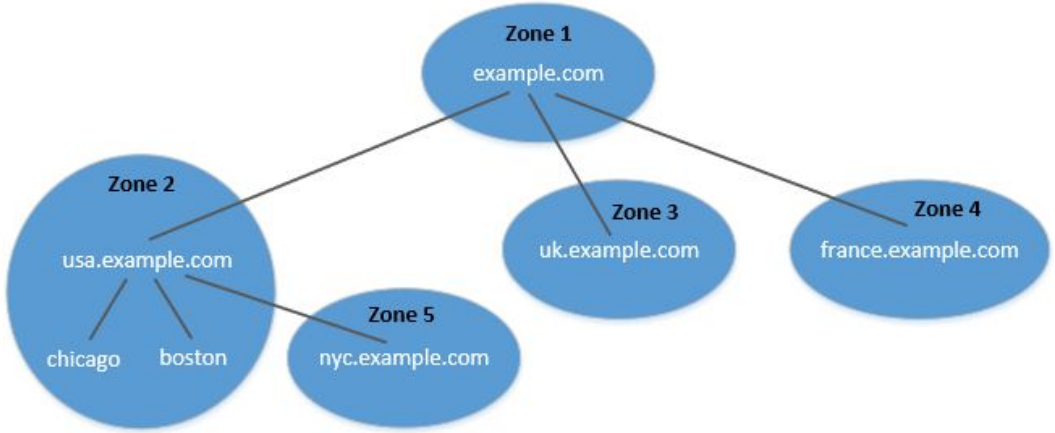
Top Level Domain

Authoritative

Client wants IP address for www.amazon.com; 1st approximation:

- client queries root server to find .com DNS server
- client queries .com DNS server to get amazon.com DNS server
- client queries amazon.com DNS server to get IP address for www.amazon.com

DNS Zone vs Domain



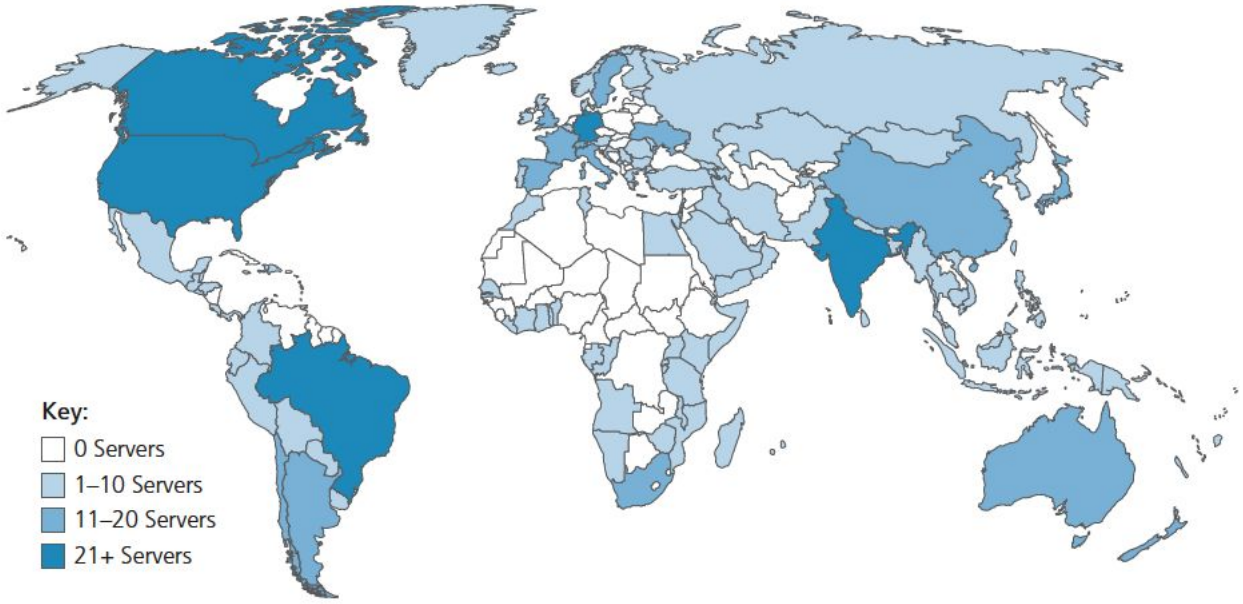
- DNS is organized according to zones.
- A zone groups contiguous domains and subdomains on the domain tree.
- Assign management authority to an entity.

- The tree structure depicts subdomains within example.com domain.
- Multiple DNS zones one for each country. The zone keeps records of who the authority is for each of its subdomains.
- The zone for example.com contains only the DNS records for the hostnames that do not belong to any subdomain like mail.example.com

DNS: root name servers

- official, contact-of-last-resort by name servers that can not resolve name
- *incredibly important* Internet function
  - Internet couldn't function without it!
  - DNSSEC – provides security (authentication and message integrity)
- ICANN (Internet Corporation for Assigned Names and Numbers) manages root DNS domain

13 logical root name "servers" worldwide each "server" replicated many times (~200 servers in US)



TLD: authoritative servers

Top-Level Domain (TLD) servers:

- responsible for .com, .org, .net, .edu, .aero, .jobs, .museums, and all top-level country domains, e.g.: .cn, .uk, .fr, .ca, .jp
- Network Solutions: authoritative registry for .com, .net TLD
- Educause: .edu TLD

Authoritative DNS servers:

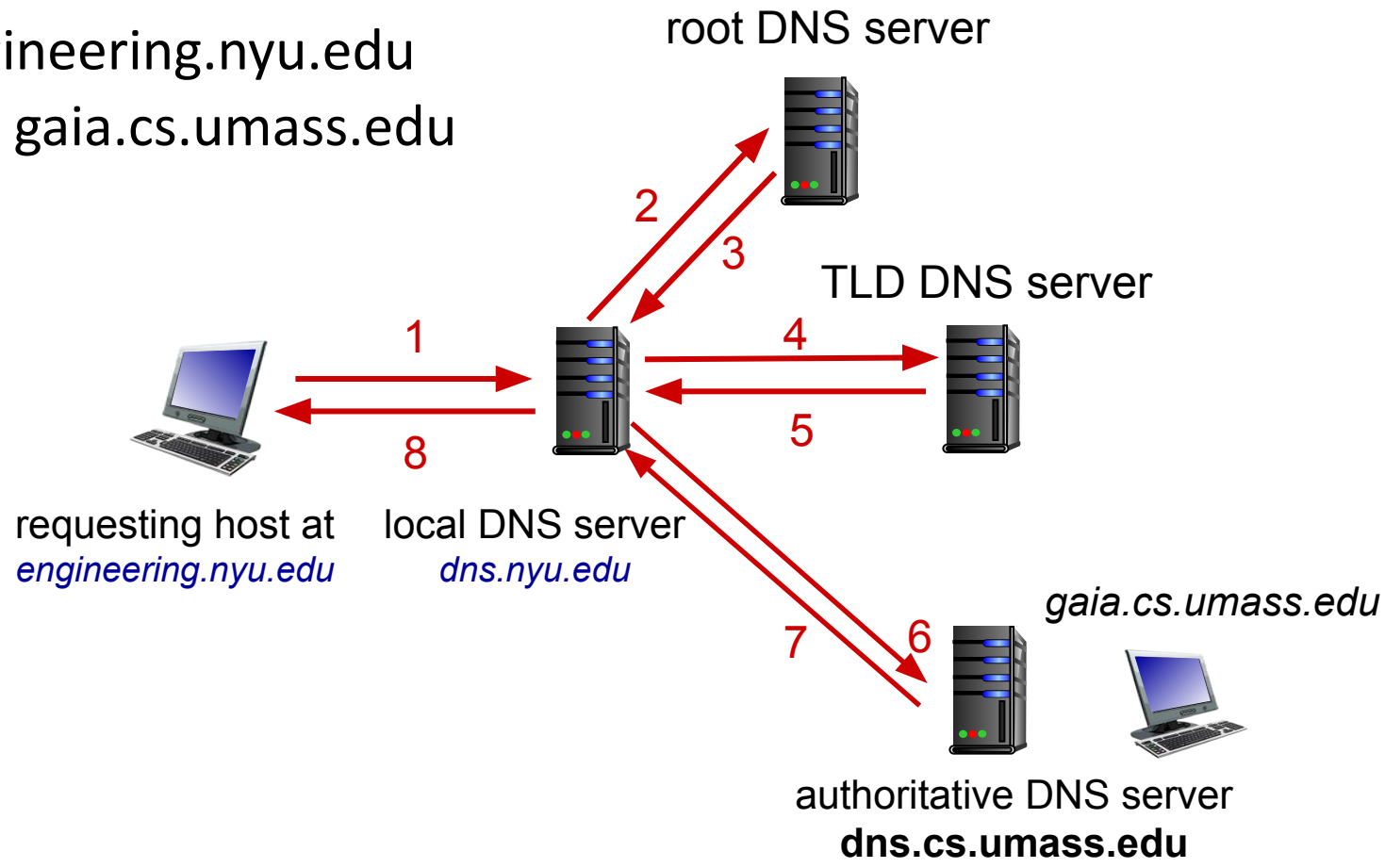
- organization's own DNS server(s), providing authoritative hostname to IP mappings for organization's named hosts
- can be maintained by organization or service provider

Local DNS Name Servers

- does not strictly belong to hierarchy
- each ISP (residential ISP, company, university) has one
  - also called “default name server”
- when host makes DNS query, query is sent to its local DNS server
  - has local cache of recent name-to-address translation pairs (but may be out of date!)
  - acts as proxy, forwards query into hierarchy

DNS name resolution: iterated query

Example: host at engineering.nyu.edu wants IP address for gaia.cs.umass.edu



Iterated query:

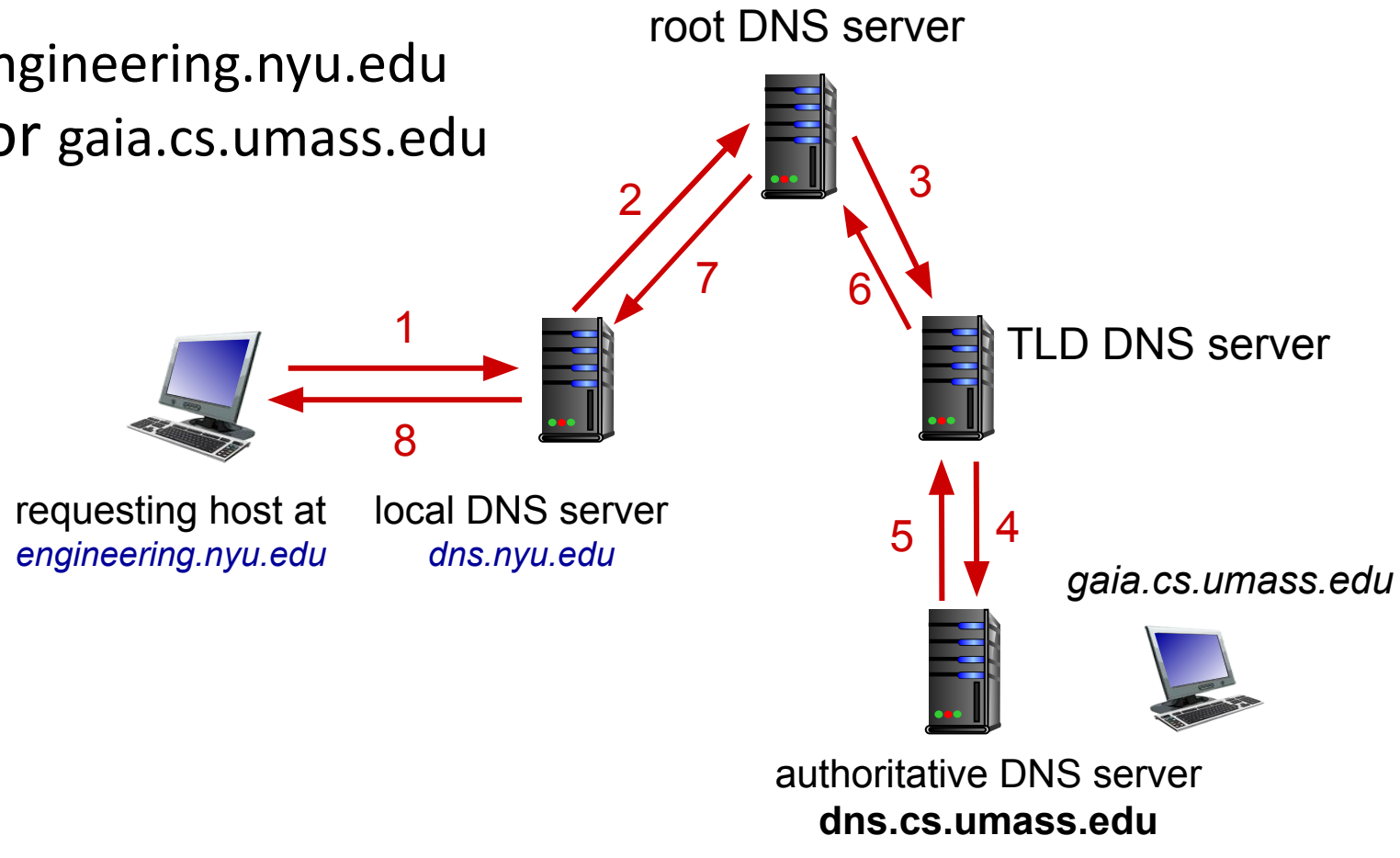
- contacted server replies with name of server to contact
- "I don't know this name, but ask this server"

DNS name resolution: recursive query

Example: host at engineering.nyu.edu wants IP address for gaia.cs.umass.edu

Recursive query:

- puts burden of name resolution on contacted name server
- heavy load at upper levels of hierarchy?



Caching and Updating DNS Records

- Suppose that a host **apricot.nyu.edu** queries **dns.nyu.edu** for the IP address for the hostname **cnn.com**. After an hour later, another NYU host, say, **kiwi.nyu.edu**, also queries **dns.nyu.edu.**
- once (any) name server learns mapping, it *caches* mapping
  - cache entries timeout (disappear) after some time (TTL)
  - TLD servers typically cached in local name servers
    - thus root name servers not often visited
- cached entries may be *out-of-date* (best-effort name-to-address translation!)
  - if name host changes IP address, may not be known Internet-wide until all TTLs expire!
- update/notify mechanisms proposed IETF standard
  - RFC 2136

DNS Records

DNS: distributed database storing resource records (RR)

RR format: (`name, value, type, ttl`)

type=A

- `name` is hostname
- `value` is IP address

relayl.bar.foo.com, 145.37.93.126, A

type=NS

- `name` is domain (e.g., foo.com)
- `value` is hostname of authoritative name server for this domain

foo.com, dns.foo.com, NS

type=CNAME

- `name` is alias name for some "canonical" (the real) name
- www.ibm.com is really servereast.backup2.ibm.com
- `value` is canonical name

ibm.com, servereast.backup2.ibm.com, CNAME

type=MX

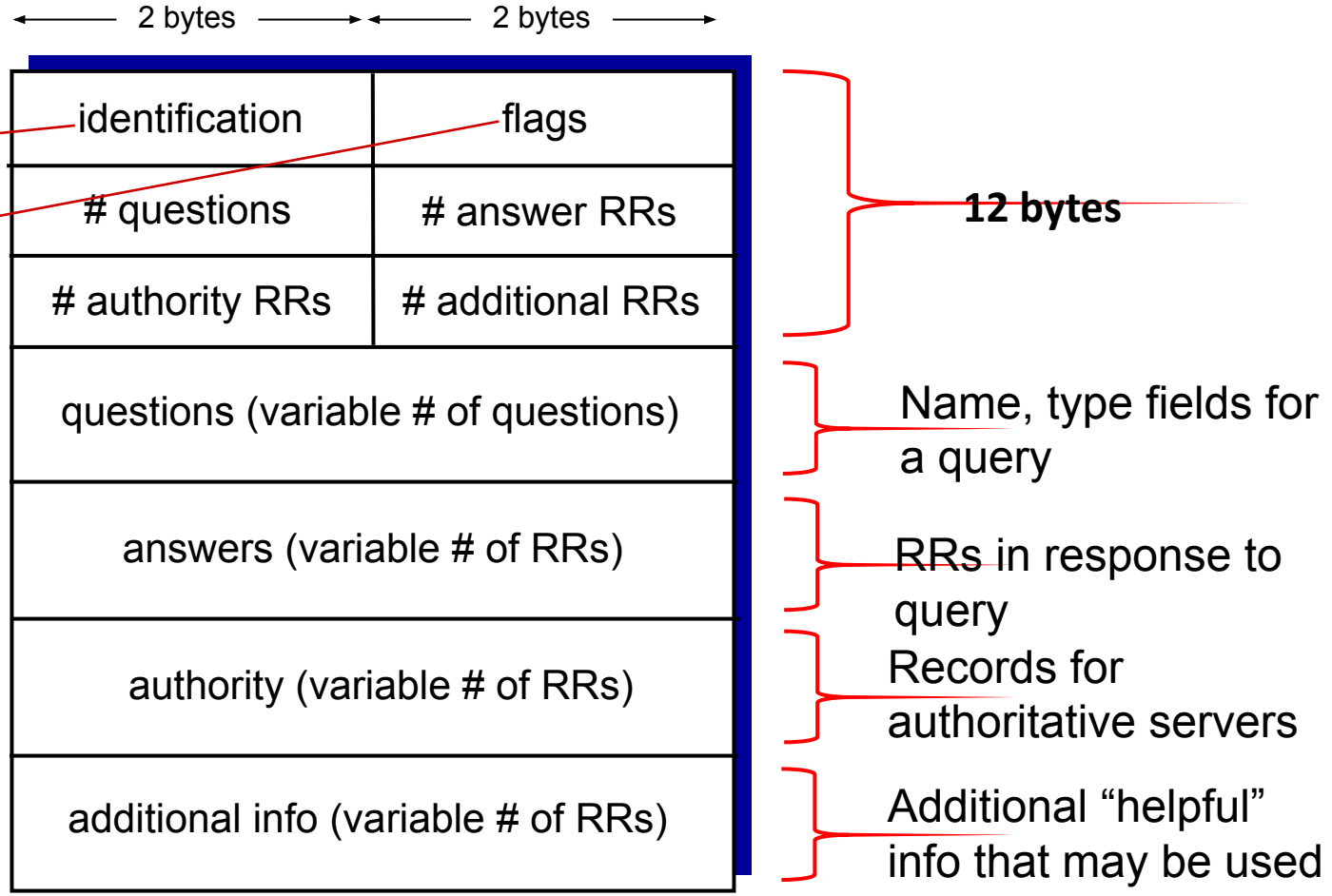
- `value` is canonical name of a mailserver associated with alias hostname `name`

example.com, mail.example.com, MX

DNS *query* and *reply* messages, both have same *format:*

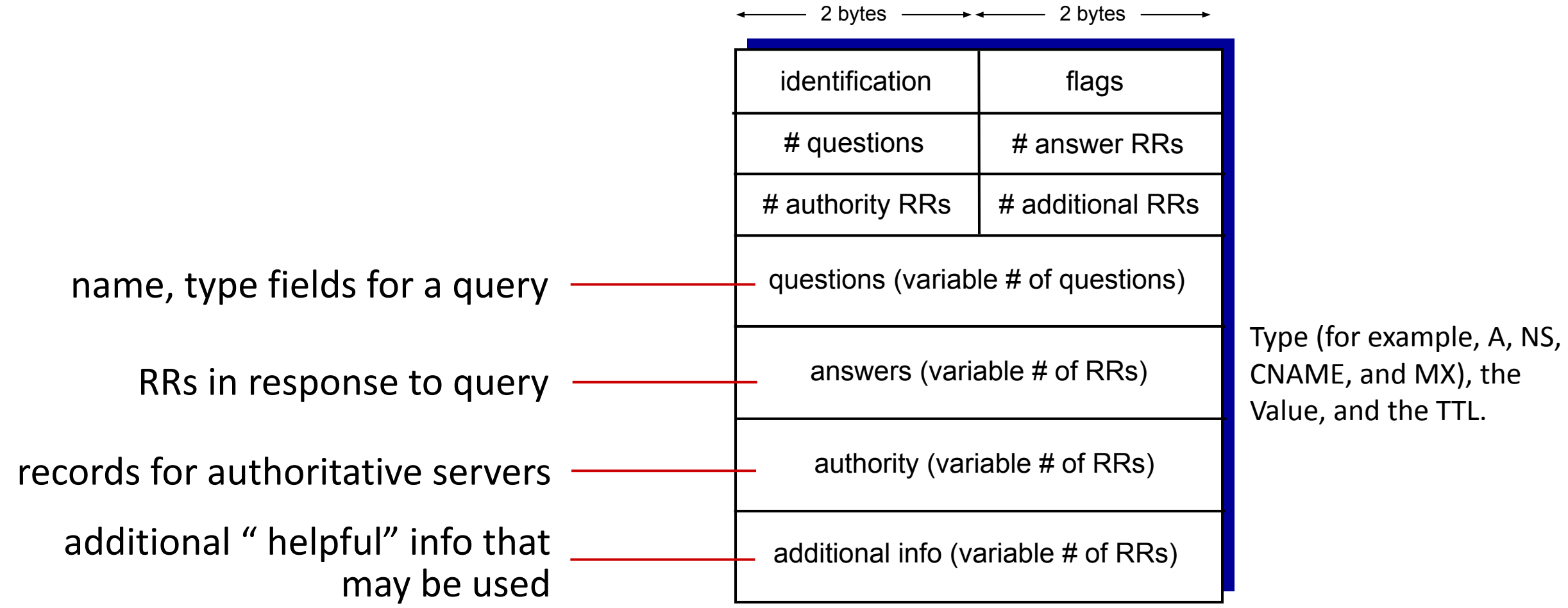
message header:

- identification: 16 bit # for query, reply to query uses same #
- flags:
  - query or reply (1-bit)
  - recursion desired
  - recursion available
  - reply is authoritative



DNS Protocol Messages

DNS *query* and *reply* messages, both have same *format:*



Emulating Local DNS Server (Step 1: Ask Root)

Directly send the query to this server.

```
seed@ubuntu:~$ dig @a.root-servers.net www.example.net

(Only a portion of the reply is shown here)
;; QUESTION SECTION:
;www.example.net.               IN      A

;; AUTHORITY SECTION:
net.                    172800  IN      NS      m.gtld-servers.net.
net.                    172800  IN      NS      l.gtld-servers.net.
net.                    172800  IN      NS      k.gtld-servers.net.

;; ADDITIONAL SECTION:
m.gtld-servers.net.     172800  IN      A       192.55.83.30
l.gtld-servers.net.     172800  IN      A       192.41.162.30
k.gtld-servers.net.     172800  IN      A       192.52.178.30
```

No answer (the root does not know the answer)

Go ask them!

Steps 2-3: Ask .net & example.net servers

```
seed@ubuntu:~$ dig @m.gtld-servers.net www.example.net

;; QUESTION SECTION:
;www.example.net.               IN      A

;; AUTHORITY SECTION:
example.net.            172800  IN      NS      a.iana-servers.net.
example.net.            172800  IN      NS      b.iana-servers.net.

;; ADDITIONAL SECTION:
a.iana-servers.net.     172800  IN      A       199.43.132.53
b.iana-servers.net.     172800  IN      A       199.43.133.53
```

Go ask them!

```
seed@ubuntu:$ dig @a.iana-servers.net www.example.net

;; QUESTION SECTION:
;www.example.net.               IN      A

;; ANSWER SECTION:
www.example.net.        86400   IN      A       93.184.216.34
```

- Ask an example.net nameservers.

Finally got the answer

Inserting records into DNS

Example: new startup “Network Utopia”

- register name **networkuptopia.com** at *DNS registrar* (e.g., Network Solutions)
  - provide names, IP addresses of authoritative name server (primary and secondary)
  - registrar inserts NS, A RRs into .com TLD server:

    `(networkutopia.com, dns1.networkutopia.com, NS)`

    `(dns1.networkutopia.com, 212.212.212.1, A)`
- create authoritative server locally with IP address `212.212.212.1`
  - type A record for www.networkuptopia.com
  - type MX record for networkutopia.com

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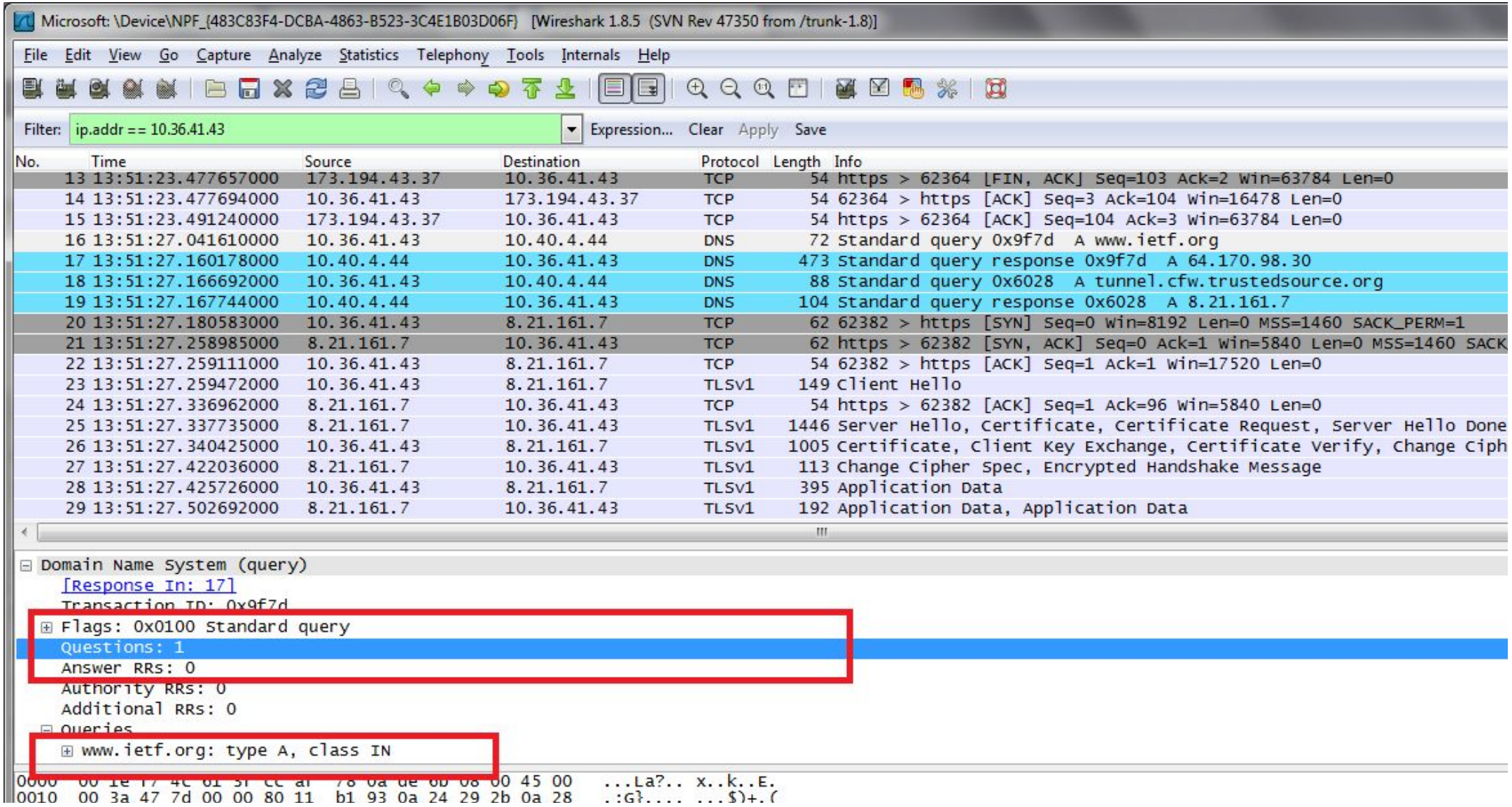
DNS Request - Wireshark Packet Capture



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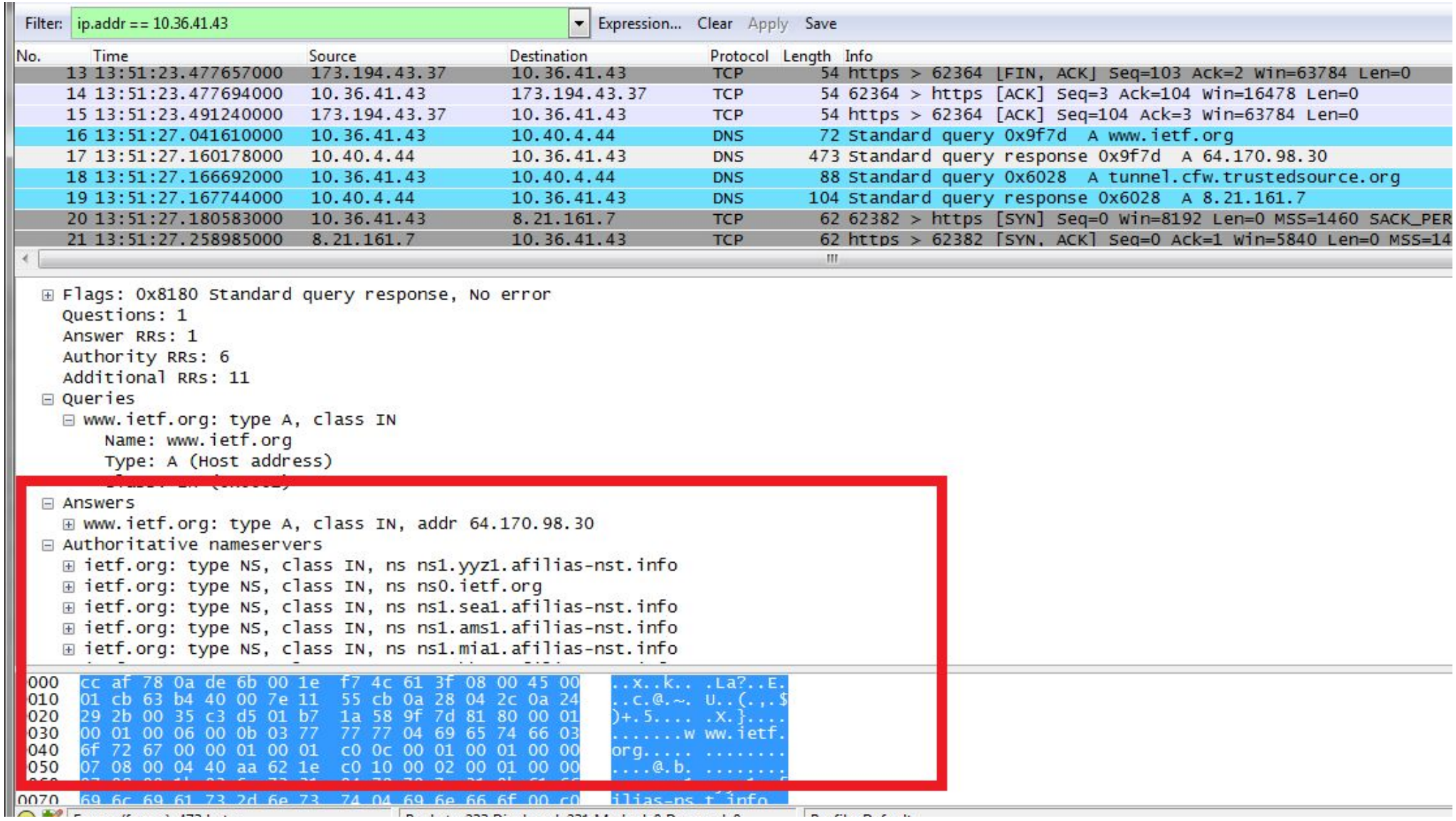
DNS Response - Wireshark Packet Capture



Suggested Readings

- DNS (Domain Name System) – Explained – https://youtu.be/JkEYOt08-rU
- How a DNS Server (Domain Name System) works – https://youtu.be/rdVPflECed8
- Wireshark Lab: DNS v7.0 – http://www-net.cs.umass.edu/wireshark-labs/Wireshark_DNS_v7.0.pdf

Thank You
For Your Attention

THANK YOU

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