NAMING AND THE DOMAIN NAME SYSTEM

George Porter
May 6, 2025

UC San Diego

ATTRIBUTION

EXAM UPDATE

- Imprints had three of their staff out sick the last few days
  - Delays in processing your exams
  - Hoping to get us the scanned exams by end of day today
  - Graded exams thus won’t be ready today

LAB 4 UPDATES

- If you have code questions, please go to a TA (or my) office hours to go over it. Please don't just post code to piazza.
- We expected you to just extend the algorithm we went over in class—one common error was using various forms of buffered Readers then switching to raw socket I/O, which fails non-deterministically
  - For testing, try on two different machines to get more realistic conditions
  - Some folks basically had a race condition that localhost testing didn't trigger that our environment did

LAB 6 NOTES

- High level step 1: Build your all-to-all "mesh"
  - Start up your server to accept incoming RPC requests
  - Then establish N-1 (or is it N?) outgoing gRPC connections to the other nodes (and yourself?)
  - Hint: you need a loop + sleep()
  - How do you know when your mesh is established?
    - Would it help to add a procedure you could call, like "Hello()" or "Ping()" or "nop()" maybe?
- High level step 2: distribute the records
  - But make sure you've got step 1 right first

LAB 6 NOTES

- Send records to remote machines *as you are reading them from the input*
  - You could try sending them individually, or in smallish batches of groups of records
- Do not read all the data into memory, then send all the records in a single gRPC call
  - For larger sort sizes, this will exceed gRPC's per-call data limits

DNS HOSTNAME VERSUS IP ADDRESS

- **DNS host name** (e.g. www.cs.ucsd.edu)
  - **Mnemonic** name appreciated by humans
  - **Variable length**, full alphabet of characters
  - Provides **little** (if any) information about **location**

- **IP address** (e.g. 128.112.136.35)
  - Numerical address appreciated by **routers**
  - **Fixed length**, decimal number
  - **Hierarchical** address space, related to host **location**

MANY USES OF DNS

- Hostname to IP address translation
  - IP address to hostname translation (reverse lookup)
- Host name aliasing: other DNS names for a host
  - Alias host names point to canonical hostname
- **Email**: Lookup domain's mail server by domain name

ORIGINAL DESIGN OF DNS

- Per-host file named /etc/hosts (1982)
  - Flat namespace: each line = IP address & DNS name
  - SRI (Menlo Park, California) kept the master copy
  - Everyone else downloads regularly
- *But, a single server doesn’t scale*
  - Traffic implosion (lookups and updates)
  - Single point of failure
- Need a distributed, hierarchical **collection** of servers

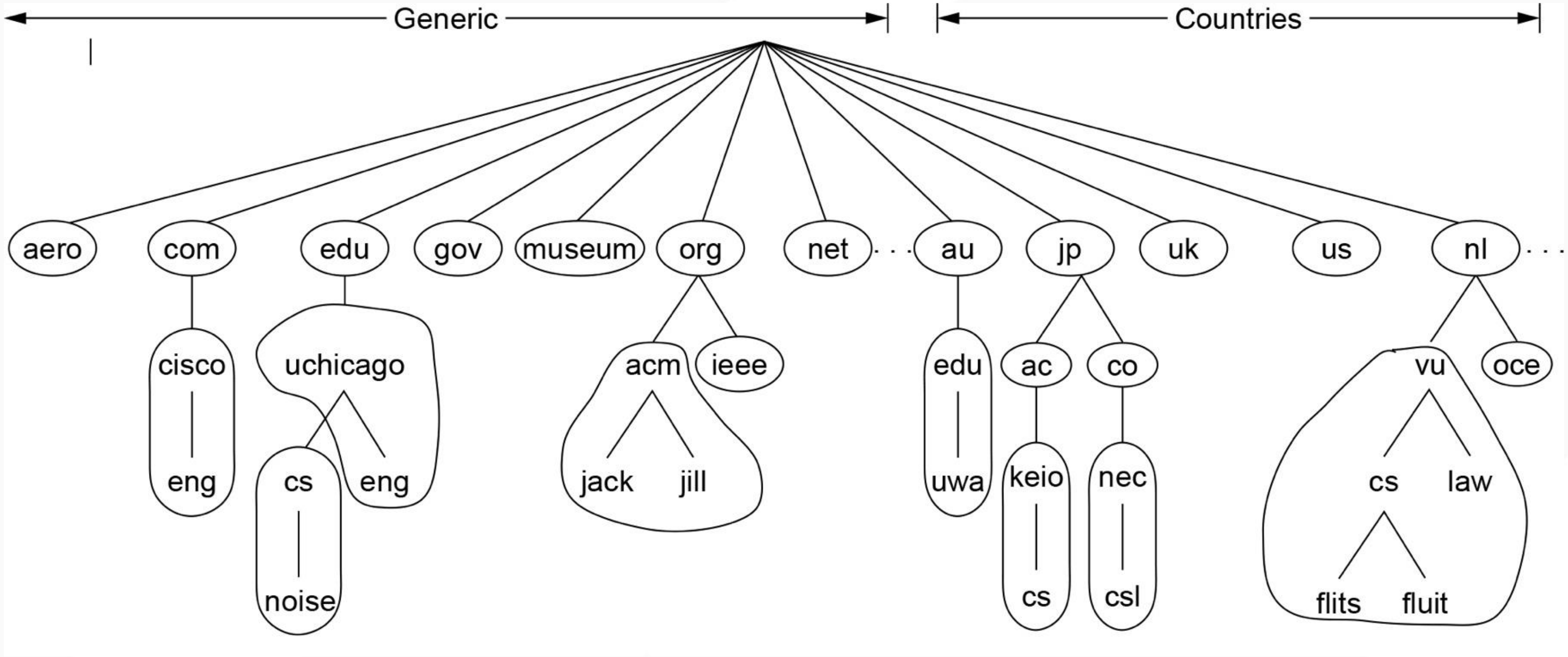
DNS: GOALS AND NON-GOALS

- A wide-area **distributed database**
- Goals:
  - **Scalability**; decentralized maintenance
  - **Robustness**
  - Global scope
    - Names mean the same thing everywhere
  - Distributed updates/queries
  - Good **performance**

DOMAIN NAME SYSTEM (DNS)

- Hierarchical name space divided into contiguous sections called zones
  - Zones are distributed over a collection of DNS servers
- Hierarchy of DNS servers:
  - Root servers (identity hardwired into other servers)
  - Top-level domain (TLD) servers
  - Authoritative DNS servers
- Performing the translations:
  - Local DNS servers located near clients
  - Resolver software running on clients

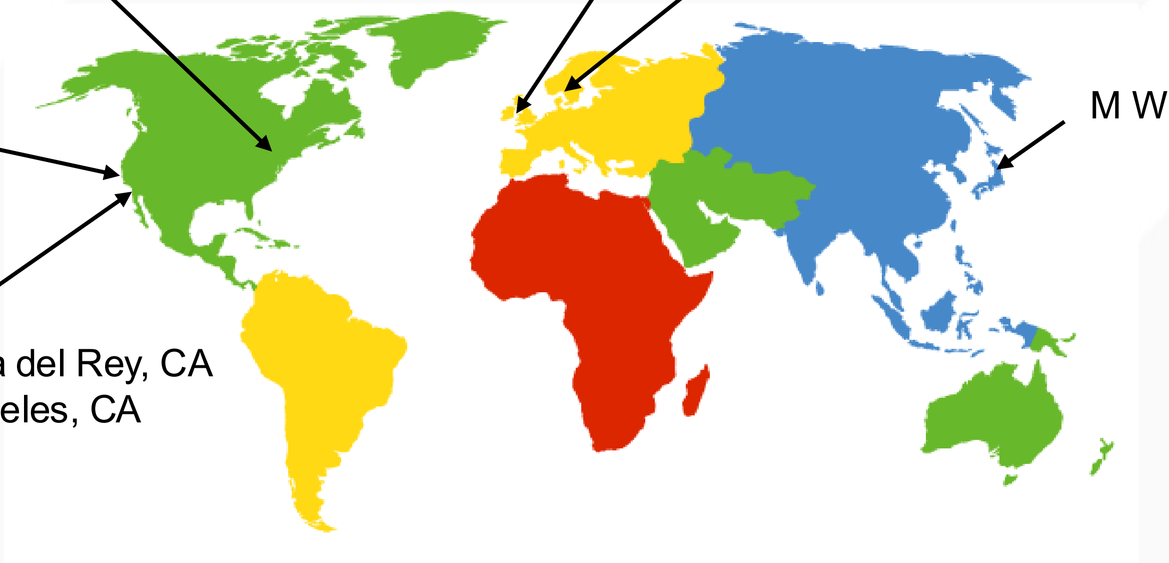
DNS IS HIERARCHICAL



- Hierarchy of namespace matches hierarchy of servers
- Set of nameservers answers queries for names within zone
- Nameservers store names and links to other servers in tree

DNS ROOT NAMESERVERS

- 13 root servers



A Verisign, Dulles, VA
C Cogent, Herndon, VA
D U Maryland College Park, MD
G US DoD Vienna, VA
H ARL Aberdeen, MD
J Verisign

I Autonomica, Stockholm

E NASA Mt View, CA
F Internet Software Consortium, Palo Alto, CA

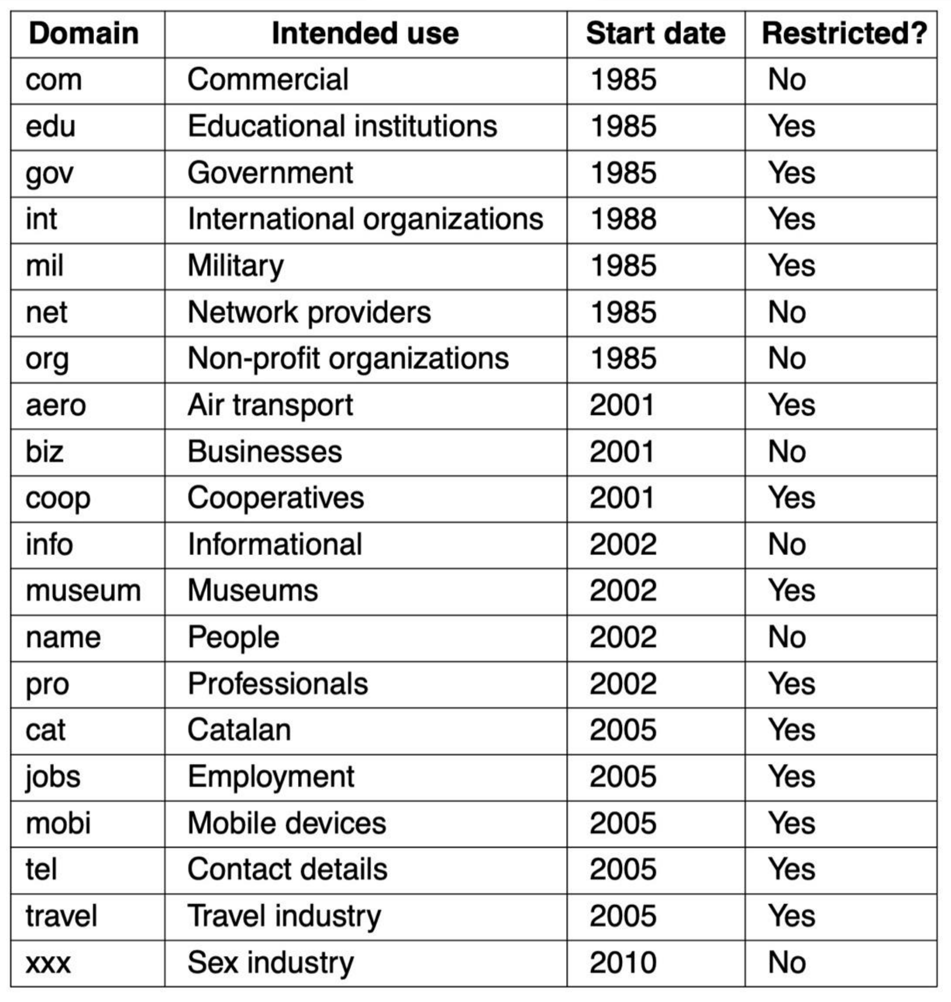
M WIDE Tokyo

B USC-ISI Marina del Rey, CA
L ICANN Los Angeles, CA

TLD AND AUTHORITATIVE SERVERS

- https://www.internic.net/domain/named.root
- Top-level domain (TLD) servers
  - Responsible for com, org, net, edu, etc, and all top-level country domains: uk, fr, ca, jp
  - Network Solutions maintains servers for com TLD
  - Educause non-profit for edu TLD
- Authoritative DNS servers
  - An organization’s DNS servers, providing authoritative information for that organization
  - May be maintained by organization itself, or ISP

COMMON TLDS



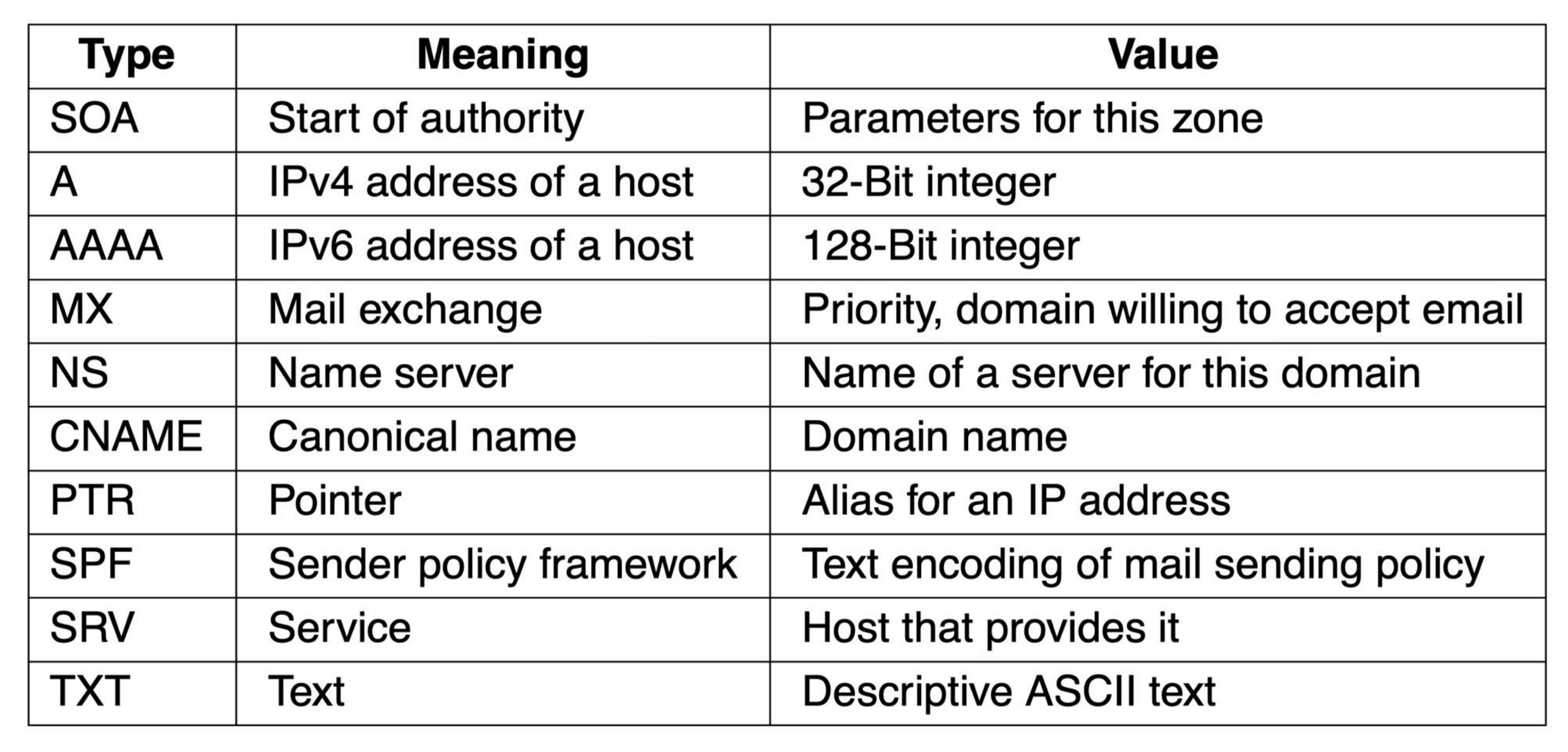
Domain	Intended use	Start date	Restricted?
com	Commercial	1985	No
edu	Educational institutions	1985	Yes
gov	Government	1985	Yes
int	International organizations	1988	Yes
mil	Military	1985	Yes
net	Network providers	1985	No
org	Non-profit organizations	1985	No
aero	Air transport	2001	Yes
biz	Businesses	2001	No
coop	Cooperatives	2001	Yes
info	Informational	2002	No
museum	Museums	2002	Yes
name	People	2002	No
pro	Professionals	2002	Yes
cat	Catalan	2005	Yes
jobs	Employment	2005	Yes
mobi	Mobile devices	2005	Yes
tel	Contact details	2005	Yes
travel	Travel industry	2005	Yes
xxx	Sex industry	2010	No

LOCAL NAME SERVERS

- Do not strictly belong to hierarchy
- Each ISP (or company, or university) has one
  - Also called default or caching name server
- When host makes DNS query, query is sent to its local DNS server
  - Acts as proxy, forwards query into hierarchy
  - Does work for the client

DNS RESOURCE RECORDS

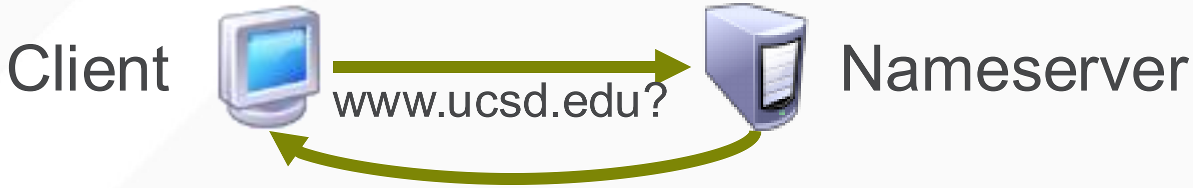
- DNS is a distributed database storing **resource records**
- Resource record includes: (**name**, type, **value**, time-to-live)



Type	Meaning	Value
SOA	Start of authority	Parameters for this zone
A	IPv4 address of a host	32-Bit integer
AAAA	IPv6 address of a host	128-Bit integer
MX	Mail exchange	Priority, domain willing to accept email
NS	Name server	Name of a server for this domain
CNAME	Canonical name	Domain name
PTR	Pointer	Alias for an IP address
SPF	Sender policy framework	Text encoding of mail sending policy
SRV	Service	Host that provides it
TXT	Text	Descriptive ASCII text

DNS IN OPERATION

- Most queries and responses are UDP datagrams
  - Two types of queries:
- ***Recursive***: Nameserver responds with answer or error



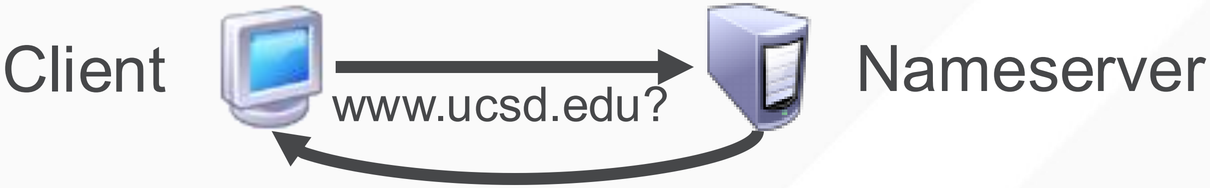
Client

www.ucsd.edu?

Nameserver

Answer: www.ucsd.edu A 132.239.180.101

- ***Iterative***: Nameserver may respond with a referral



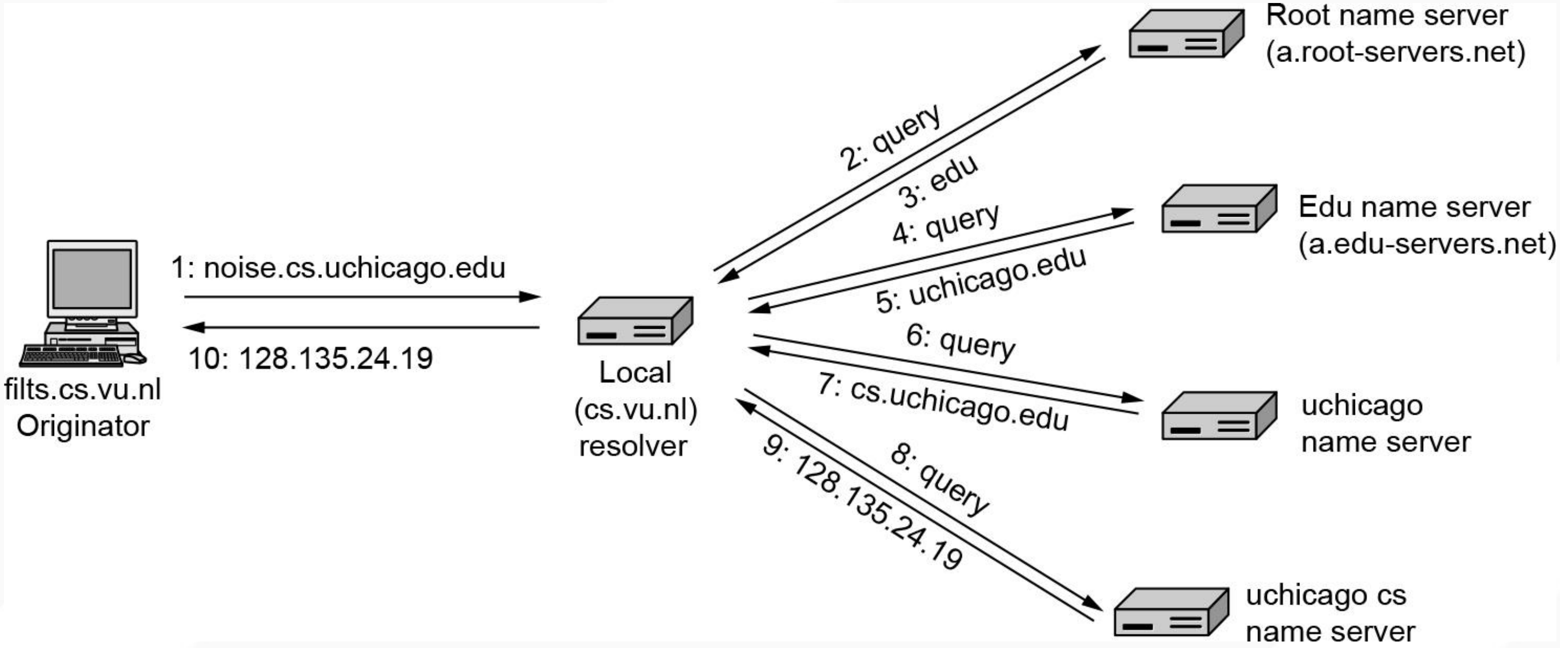
Client

www.ucsd.edu?

Nameserver

Referral: .edu NS a.edu-servers.net.

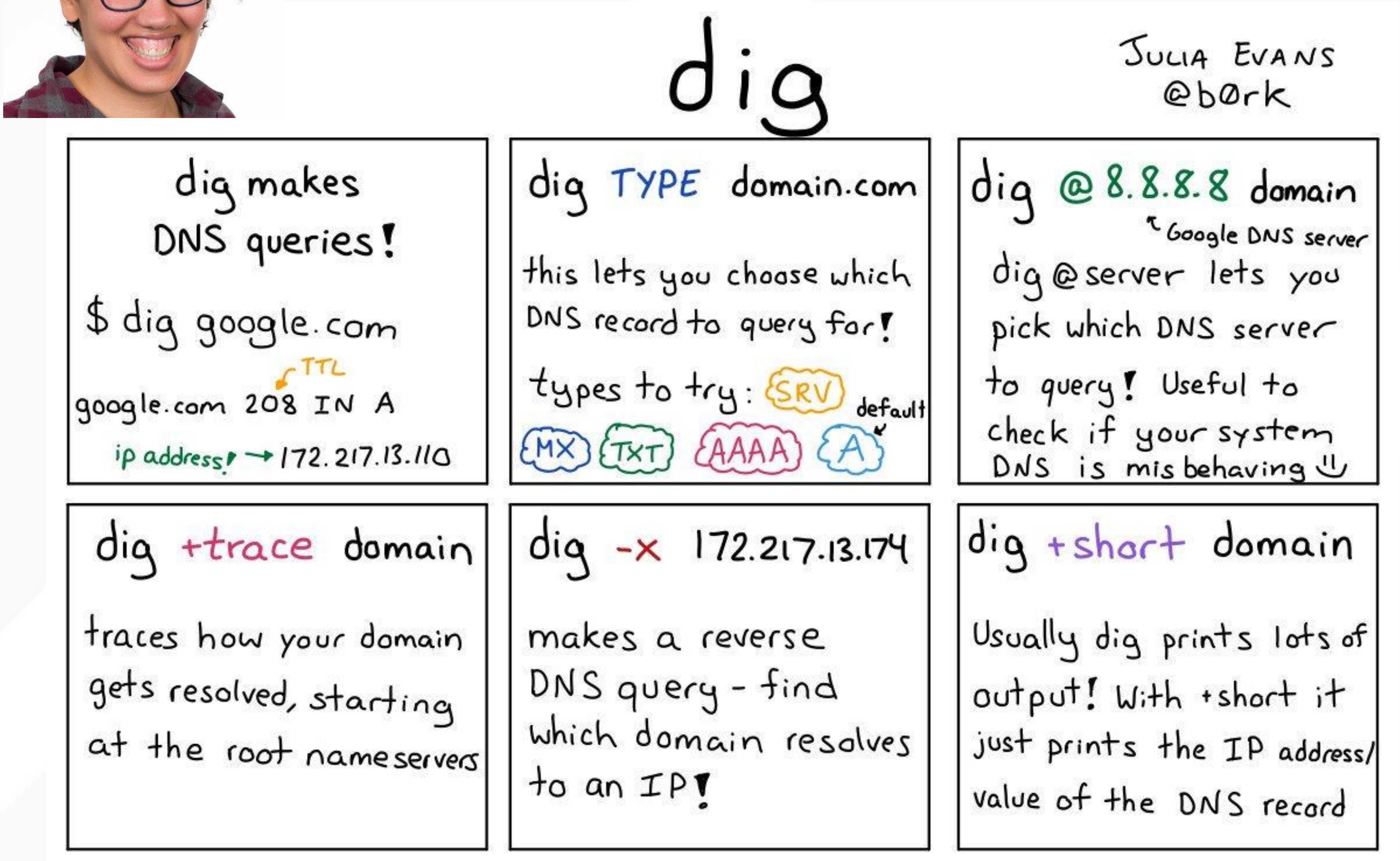
ITERATIVE LOOKUP



DNS CACHING

- Performing all these queries takes time
  - And all this before actual communication takes place
- Caching can greatly reduce overhead
  - The top-level servers very rarely change
    - Popular sites visited often
  - Local DNS server often has the information cached
- How DNS caching works
  - All DNS servers **cache responses to queries**
  - Responses include a time-to-live (TTL) field
    - Server deletes cached entry after TTL expires

JULIA EVAN'S GUIDE TO *DIG*



dig

JULIA EVANS
@b0rk

dig makes DNS queries!

```
$ dig google.com
```

TTL

```
google.com 208 IN A
```

ip address! → 172.217.13.110

```
dig TYPE domain.com
```

this lets you choose which DNS record to query for!

types to try: SRV MX TXT AAAA A

default

```
dig @8.8.8.8 domain
```

Google DNS server

dig @server lets you pick which DNS server to query! Useful to check if your system DNS is misbehaving ☺

```
dig +trace domain
```

traces how your domain gets resolved, starting at the root nameservers

```
dig -x 172.217.13.174
```

makes a reverse DNS query - find which domain resolves to an IP!

```
dig +short domain
```

Usually dig prints lots of output! With +short it just prints the IP address/value of the DNS record

GO DEMOS

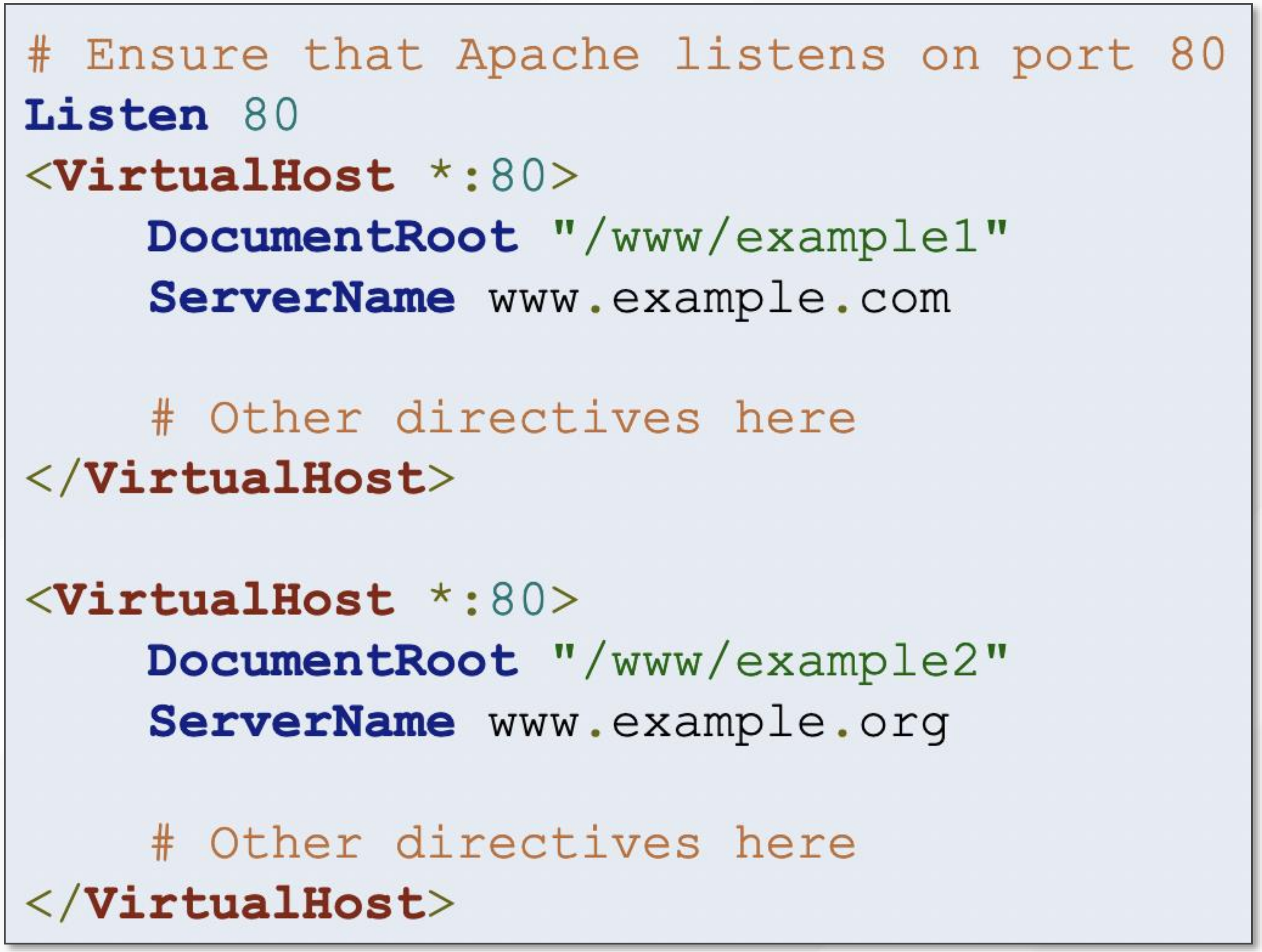
- From the networking with Go book, ch 3

```
$ go run lookuphost.go go.dev
```

compare to

```
$ dig go.dev A go.dev AAAA +short
```

VIRTUAL HOSTING (APACHE CONFIG FILE EXAMPLE)



```
# Ensure that Apache listens on port 80
Listen 80
<VirtualHost *:80>
    DocumentRoot "/www/example1"
    ServerName www.example.com

    # Other directives here
</VirtualHost>

<VirtualHost *:80>
    DocumentRoot "/www/example2"
    ServerName www.example.org

    # Other directives here
</VirtualHost>
```

LET’S TRY IT…

- http://sockets.sysnet.ucsd.edu
- http://www.sysnet.ucsd.edu

- How can we use ‘dig’, ‘nc’, and ‘printf’ to verify whether virtual hosting is involved in these two websites?

UC San Diego