

# Internet Naming & Addressing

Objectives: How do we name and address machines in the Internet? What are mnemonic names vs. IP addresses? How do we translate between the two? Understand DNS as a distributed naming infrastructure: design principles, hierarchy & scalability, iterative vs. recursive queries, caching, types of DNS records. Introduction of network tools: `nslookup(1)` and `dig(1)`.

NS4: March 27, 2018

Textbook (K&R): Sections 2.1, 2.5

# Two tales of Internet names

- How did you name your traceroute/ping targets?
  - [www.csail.mit.edu](http://www.csail.mit.edu), [www.cs.purdue.edu](http://www.cs.purdue.edu) (mnemonic name; some hierarchy encoded)
- But, machines like binary (bits & bytes)
  - IPv4 address: 32 bits specifically
  - 128.30.2.155 (dotted notation: a.b.c.d; letter = unsigned byte/octet)
  - Also hierarchical: facilitates routing (remote router uses short *prefix* of destination IP address only to decide next hop – much smaller routing table)
- Need translation from name to IP address (via DNS)

# DNS: domain name system

*people:* many identifiers:

- NRIC/FIN number, name, passport #

*Internet hosts, routers:*

- IP address (32 bit) - used for addressing datagrams
- “name”, e.g.,  
www.yahoo.com - 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”

# DNS: services, structure

## *DNS services*

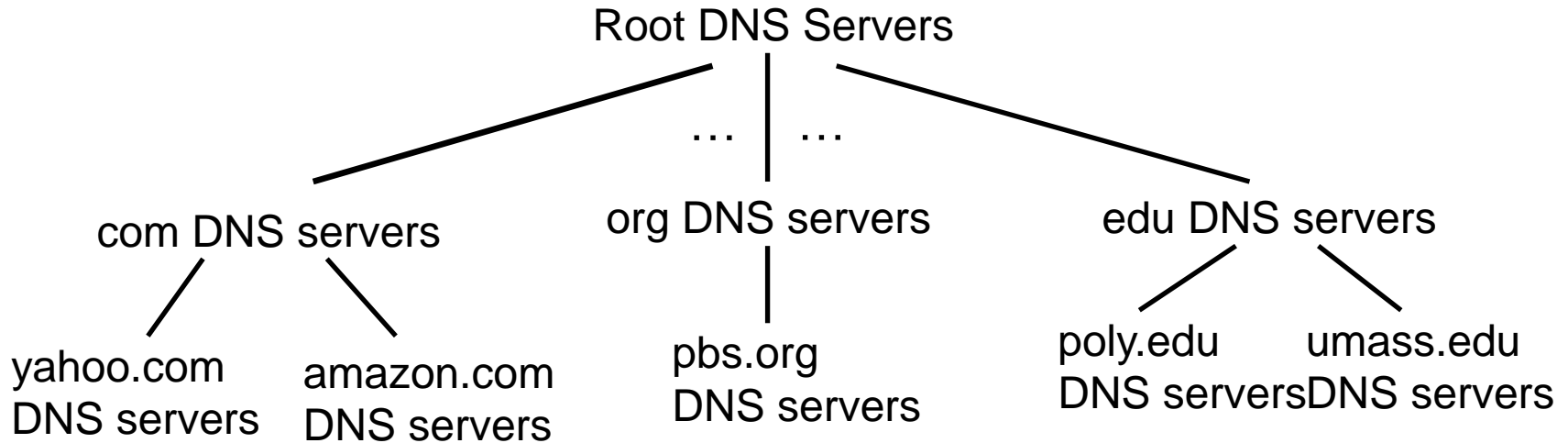
- hostname to IP address translation
- host aliasing
  - canonical, alias names
- mail server aliasing
- load distribution
  - replicated Web servers:  
many IP addresses  
correspond to one  
name

## *why not centralize DNS?*

- single point of failure
- traffic volume (bottleneck)
- distant centralized database (long delays for lookups)
- maintenance (add/delete/change translations)

*A: doesn't scale!*

# DNS: a distributed, hierarchical database

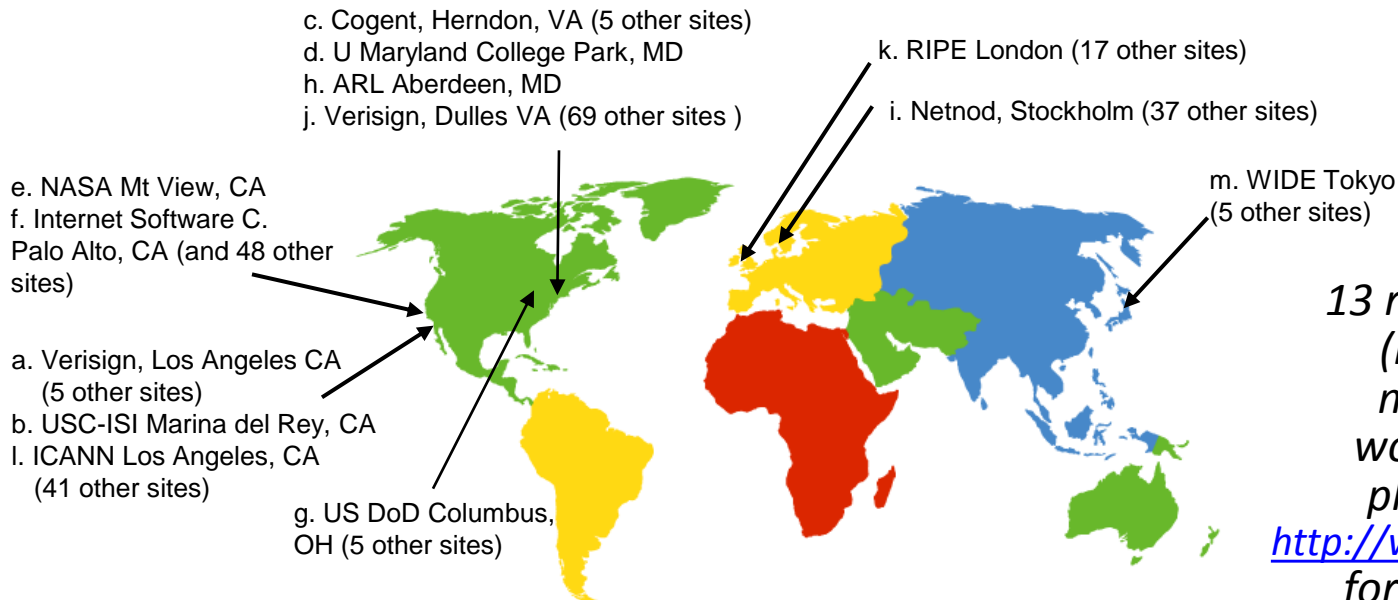


*client wants IP for www.amazon.com; 1<sup>st</sup> approx:*

- 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: root name servers

- contacted by local name server that can not resolve name
- root name server:
  - contacts authoritative name server if name mapping not known
  - gets mapping
  - returns mapping to local name server



*13 root name “servers”  
(logical, also called  
named authorities)  
worldwide – over 400  
physical servers; see  
<http://www.root-servers.org/>  
for current situation*

# 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.: uk, fr, ca, jp, sg
- Verisign Global Registry Services maintains servers for .com TLD
- Educause for .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 server

- 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

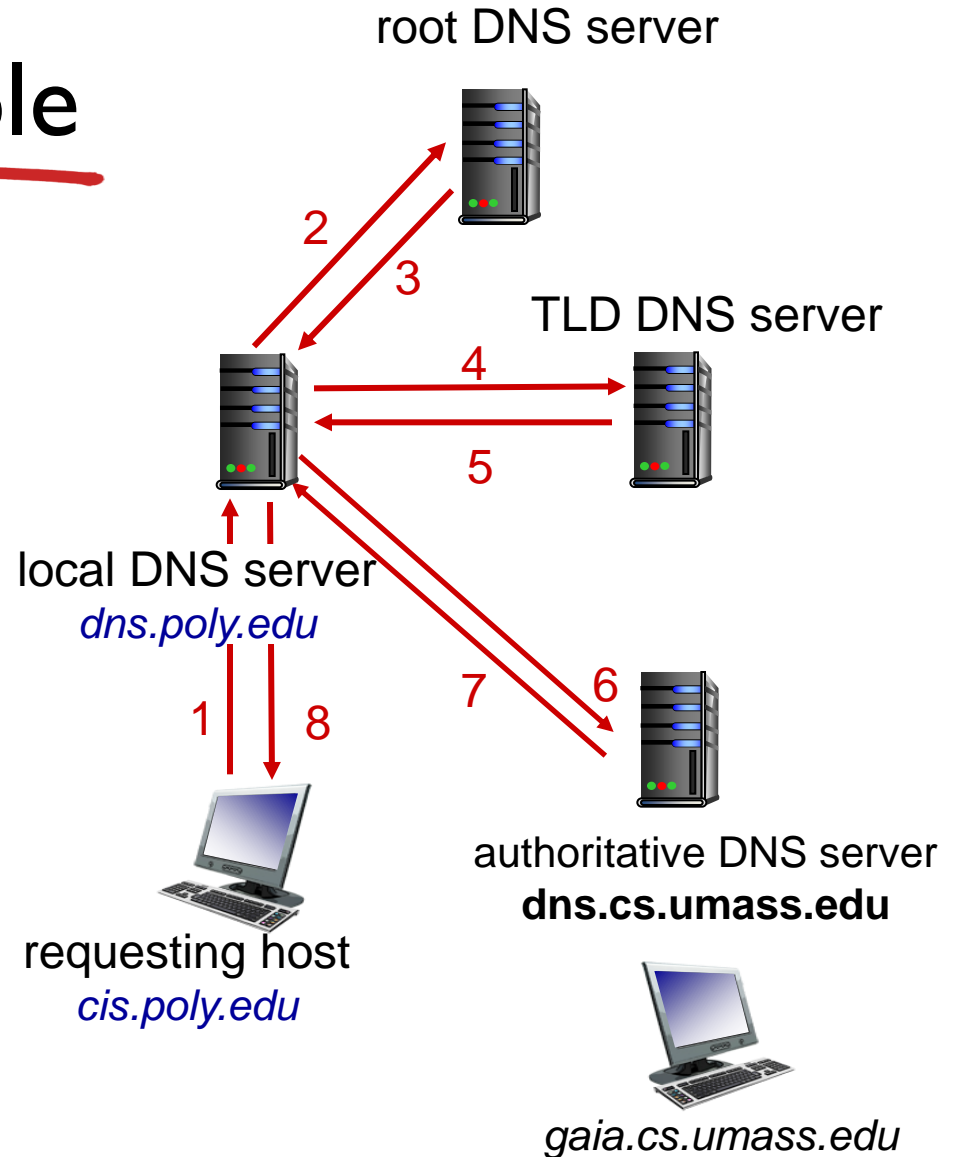


# DNS name resolution example

- host at cis.poly.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 example

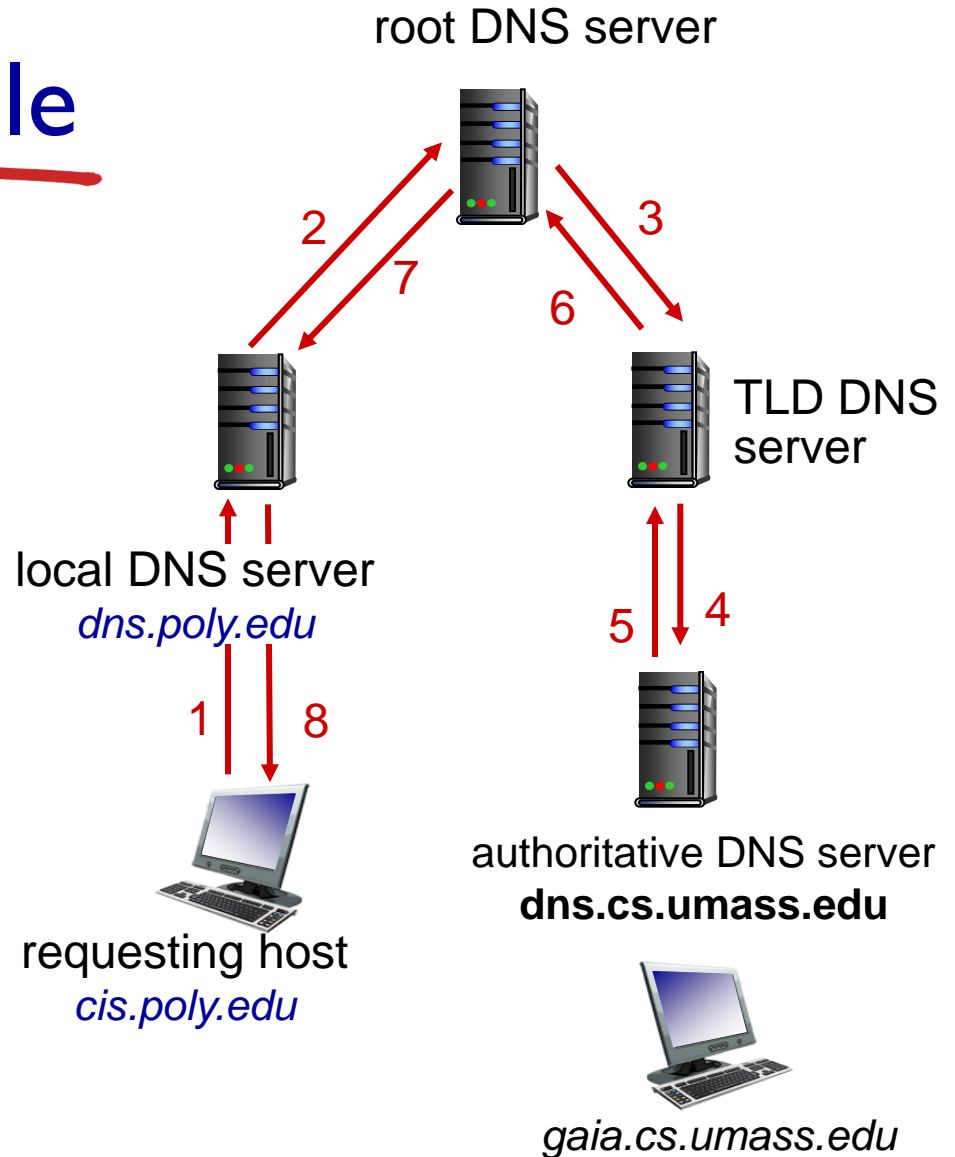
## *recursive query:*

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

Who (client or server) decides iterated vs. recursive?

How many servers are willing to support recursion? See:

<https://www.us-cert.gov/security-publications/continuing-denial-service-threat-posed-dns-recursion-v20>



# DNS: caching, updating records

- 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
  - who (client or server?) sets the TTL?
- update/notify mechanisms proposed IETF standard
  - RFC 2136

# DNS records

**DNS:** distributed db storing resource records (RR)

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

## type=A

- **name** is hostname
- **value** is IP address

## type=NS

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

## 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

## type=MX

- **value** is name of mailserver associated with **name**

NB: “name” here is lookup key, “value” is result of the lookup

# DNS protocol, messages

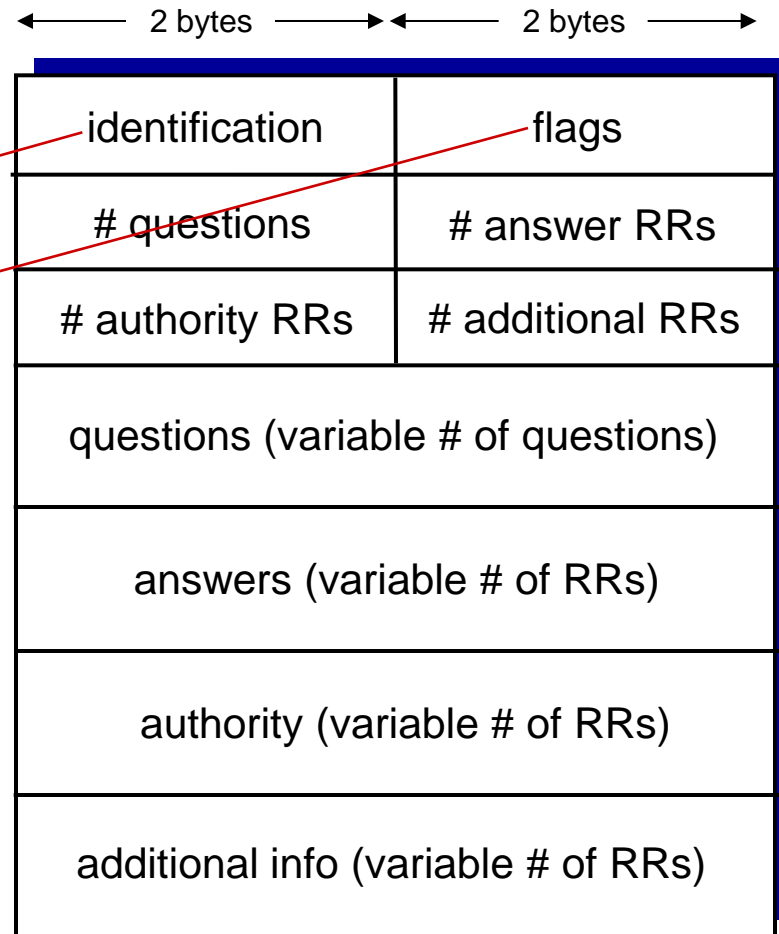
- *query* and *reply* messages, both with same *message format*

## msg header

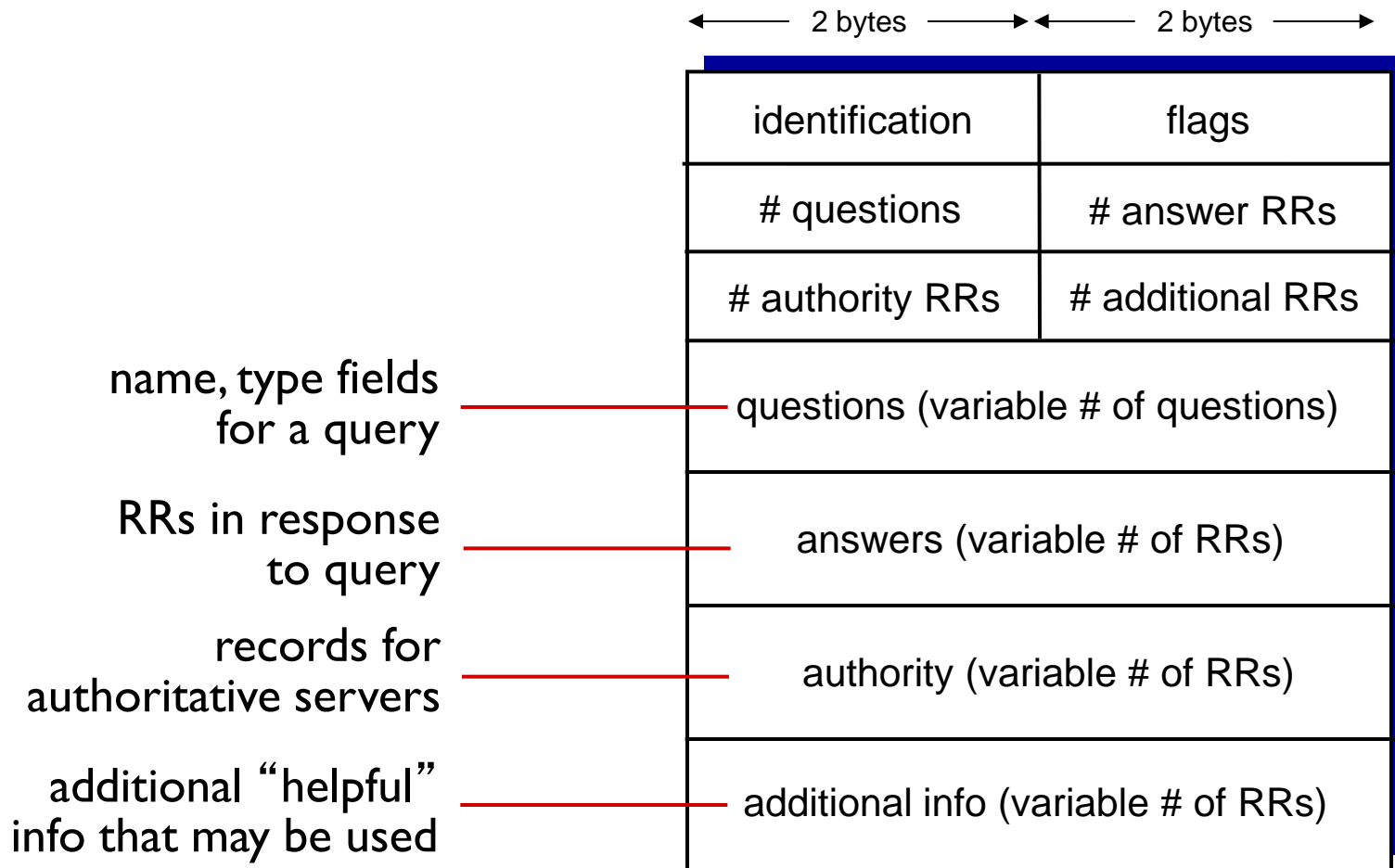
- ❖ **identification**: 16 bit # for query, reply to query uses same #
- ❖ **flags**:
  - query or reply
  - recursion desired
  - recursion available
  - reply is authoritative

Q: What is the size of a DNS message?

A: Don't know (depending on # of RRs in each section). Generally, replies larger than queries – can be much larger).



# DNS protocol, messages



# Inserting records into DNS

- example: new startup “Network Utopia”
- register name networkutopia.com at *DNS registrar* (e.g., Verisign registry)
  - provide names, IP addresses of authoritative name server (primary and secondary)
  - registrar inserts two RRs into .com TLD server:  
`(networkutopia.com, dns1.networkutopia.com, NS)`  
`(dns1.networkutopia.com, 212.212.212.1, A)`
- create authoritative server type A record for `www.networkutopia.com`; type MX record for `networkutopia.com`

# Attacking DNS

## DDoS attacks

- Bombard root servers with traffic
  - Not successful to date
  - Traffic Filtering
  - Local DNS servers cache IPs of TLD servers, allowing root server bypass
- Bombard TLD servers
  - Potentially more dangerous

## Redirect attacks

- ❖ Man-in-middle
  - Intercept queries
- ❖ DNS poisoning
  - Send bogus replies to DNS server, which caches

## Exploit DNS for DDoS

- ❖ Send queries with spoofed source address: target IP
- ❖ Requires amplification



# DNS poisoning slams web traffic from millions in China into the wrong hole

ISP blames unspecified attack for morning outage

By John Leyden, 21 Jan 2014 [Follow](#) 2,451 followers

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A widespread DNS outage hit China on Tuesday, leaving millions of surfers adrift.

DNS issues in China between 7am and 9am GMT left millions of domains inaccessible. Two-thirds of China's DNS (Domain Name System) infrastructure was blighted by the incident, which stemmed from a cache poisoning attack.

Chinese netizens were left unable to visit websites or use social media and instant messaging services as a result of the screw-up, the Hong Kong-based *South China Morning Post* [reports](#).

The snafu, which affected China's root servers, meant all queries resolve to the IP address 65.49.2.178. A fix was implemented around two hours after the snag first surfaced.

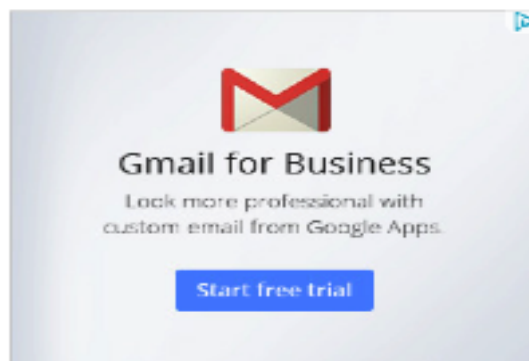
All China's generic top-level domain names were affected. Services provided by local internet giants such as search engine Baidu and social-media portal Sina.com were rendered unavailable to locals unless they accessed them through virtual private network (VPN) technology.

DNS servers provide a lookup function that converts domain names, such as "www.baidu.com," into a numerical IP address understood by routers and servers.

The cause of the problem, which might take up to 12 hours to be fully resolved, was not immediately clear, with an attack by hackers being at least one of the possible reasons.

DNSPod, a DNS provider that describes itself as the largest in the country, handling three million domains, put out an [update](#) on Twitter blaming an attack without going into details.

More coverage of the incident can be found in a story by the *Wall Street Journal* [here](#). ®



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# Activity 4.1: DNS via nslookup

Davids-MacBook-Pro-2:~ david\_yau\$ nslookup www.csail.mit.edu

Server: 202.65.247.31

Address: 202.65.247.31#53

Non-authoritative answer:

Name: www.csail.mit.edu

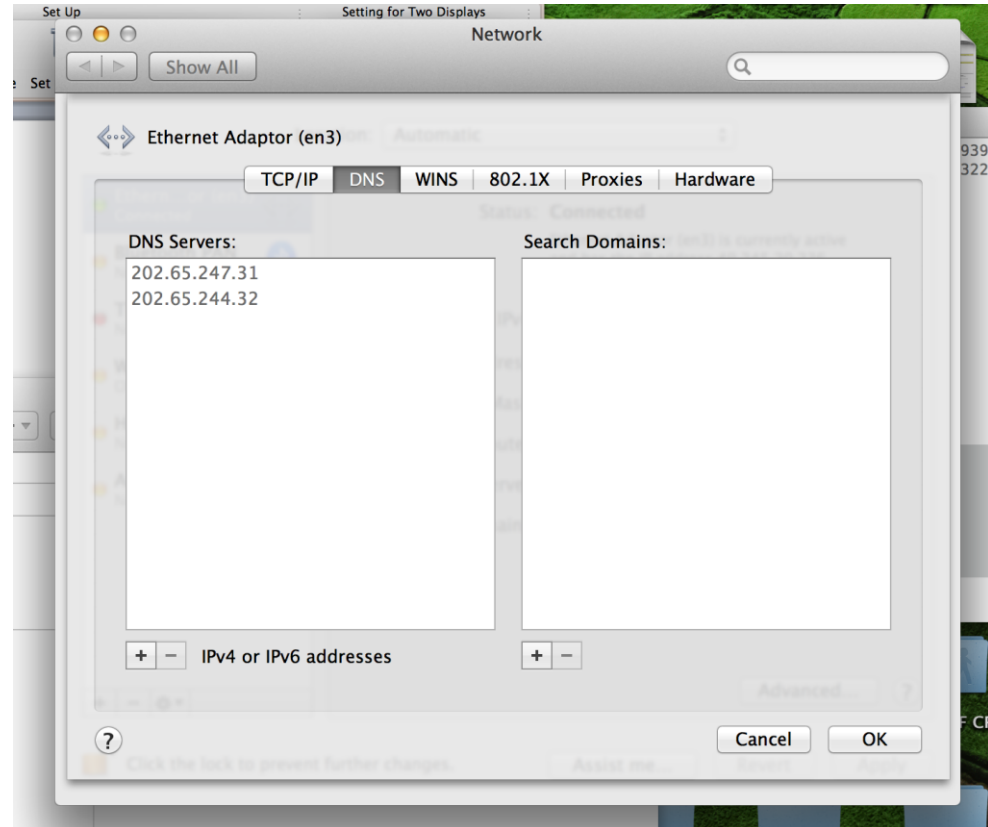
Address: 128.30.2.155

What's IP addr of www.csail.mit.edu?

Who provided the answer?

What is 202.65.247.31?

Why is the answer non-authoritative?



# Activity 4.2: DNS via dig

1. Familiarize yourself with the dig tool

`% man -s 1 dig`

2. You'd like to email [leighton@mit.edu](mailto:leighton@mit.edu). Find the email server you should use.

3. How many answers did you get? Why might it be useful to have more than one answer?

4. Now find the IP address of the first server.

5. Use whois to verify the organization that owns the IP address in Q4.

You can use either the command line, or <http://who.domaintools.com>

# Activity 4.3: dig from M1 can see more!

```
236:~ david_yau$ dig mit.edu MX
```

```
...
```

```
;; ANSWER SECTION:
```

```
mit.edu. 120 IN MX 100 dmz-mailsec-scanner-4.mit.edu.  
mit.edu. 120 IN MX 100 dmz-mailsec-scanner-5.mit.edu.  
mit.edu. 120 IN MX 100 dmz-mailsec-scanner-6.mit.edu.  
mit.edu. 120 IN MX 100 dmz-mailsec-scanner-7.mit.edu.  
mit.edu. 120 IN MX 100 dmz-mailsec-scanner-8.mit.edu.  
mit.edu. 120 IN MX 100 dmz-mailsec-scanner-1.mit.edu.  
mit.edu. 120 IN MX 100 dmz-mailsec-scanner-2.mit.edu.  
mit.edu. 120 IN MX 100 dmz-mailsec-scanner-3.mit.edu.
```

```
;; AUTHORITY SECTION:
```

```
mit.edu. 10073 IN NS ns1-37.akam.net.  
mit.edu. 10073 IN NS use2.akam.net.  
mit.edu. 10073 IN NS asia2.akam.net.  
mit.edu. 10073 IN NS ns1-173.akam.net.  
mit.edu. 10073 IN NS asia1.akam.net.  
mit.edu. 10073 IN NS use5.akam.net.  
mit.edu. 10073 IN NS eur5.akam.net.  
mit.edu. 10073 IN NS usw2.akam.net.
```

```
;; ADDITIONAL SECTION:
```

```
dmz-mailsec-scanner-1.mit.edu. 1800 IN A 18.9.25.12
```

1. What “extra” answers did I get? *Ans: those RRs in AUTHORITY section.*
2. What is the DNS type of the “extra” records returned? What does the type mean?
3. Ask your local DNS server to find the IP address of dmz-mailsec-scanner-3.mit.edu.
4. Now use the authoritative name server asia2.akam.net to do the resolution in Q3. Do the two answers agree?
5. What’s the IP addr. of asia2.akam.net?
6. Use whois to find out who owns the IP address in Q5.
7. Do a web search for the company in Q6, and briefly describe the company’s business.

# Reflections on DNS

- Protection domains to the next level (cf. OS processes)
  - Different *physical machines*: strong modularity, strong fault isolation
- Distributed (hierarchical) servers: scalability
- *Indirection* (name to IP addr) as design principle has many virtues
  - Late binding: runtime
  - Many-to-one mappings
  - One-to-many mappings
- Cost of indirection?
  - Delay (overhead), security (poisoned/intercepted mappings)

Server can move

Aliasing

Load balancing