CS 330: Network Applications & Protocols

Application Layer: DNS

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Overview of Application Layer

- **Network Application Architectures**
- **HyperText Transfer Protocol (HTTP)**
- **File Transfer and Email protocols (FTP, SMTP)**
- **Domain Name System (DNS)**
  - Function
  - Distributed Structure
  - DNS Caching
  - DNS Records
  - DNS Vulnerabilities
- **Peer-to-Peer Applications (P2P)**

DNS: Domain Name System

- **DNS servers translate a host name to IP address**
  - e.g. www.ycp.edu ➔ 54.210.214.116
  - Would be painful to browse Internet and remember IP addresses
- **Hosts and name servers communicate to resolve names**
  - address ➔ name translation

- **Distributed database of all hosts in the universe**
  - Avoids single point of failure
  - Distributes name resolution traffic
  - Geographically distributed
  - Easier to maintain

- **Often used by other application-layer protocols (e.g. SMTP, HTTP, FTP) to translate hostnames to IP addresses**

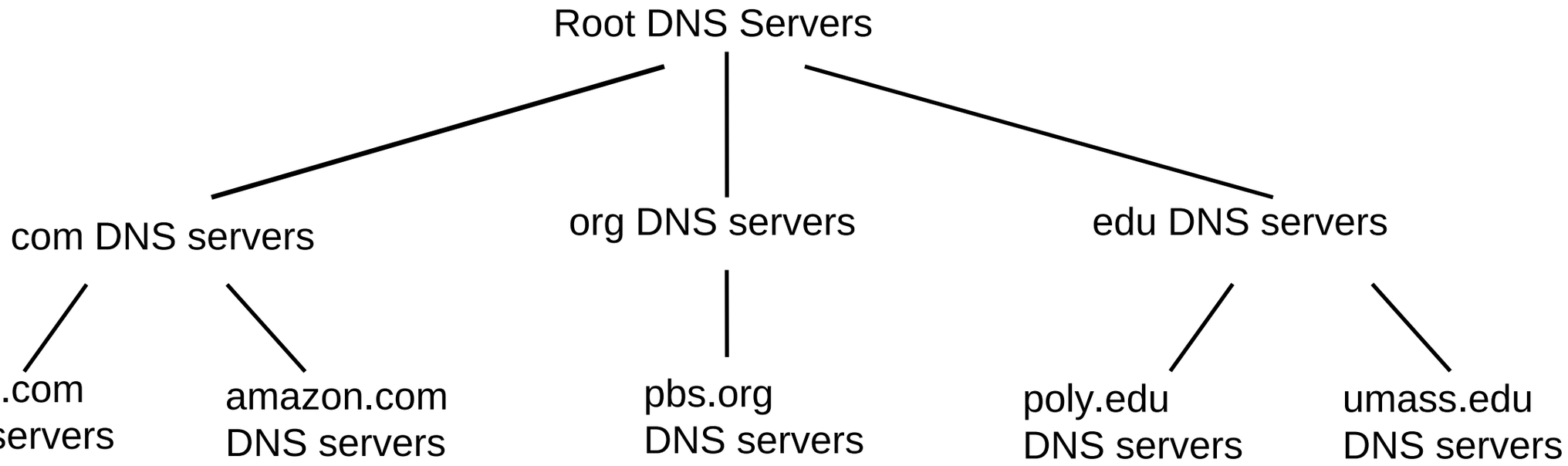
Other Services Provided By DNS

- **Host aliasing**
  - Provides canonical name when alias name is provided
  - www.gmail.com ➔ googlemail.l.google.com
- **Mail server aliasing**
- **Load distribution**
  - Why not centralize DNS?
  - Replicated web servers, many IP addresses correspond to one name

DNS Example

- **`Nslookup -type=a yahoo.com`**
- **`Nslookup -type=ns yahoo.com`**
- **`Nslookup -query=mx yahoo.com`**
- **`Nslookup -type=any yahoo.com`**

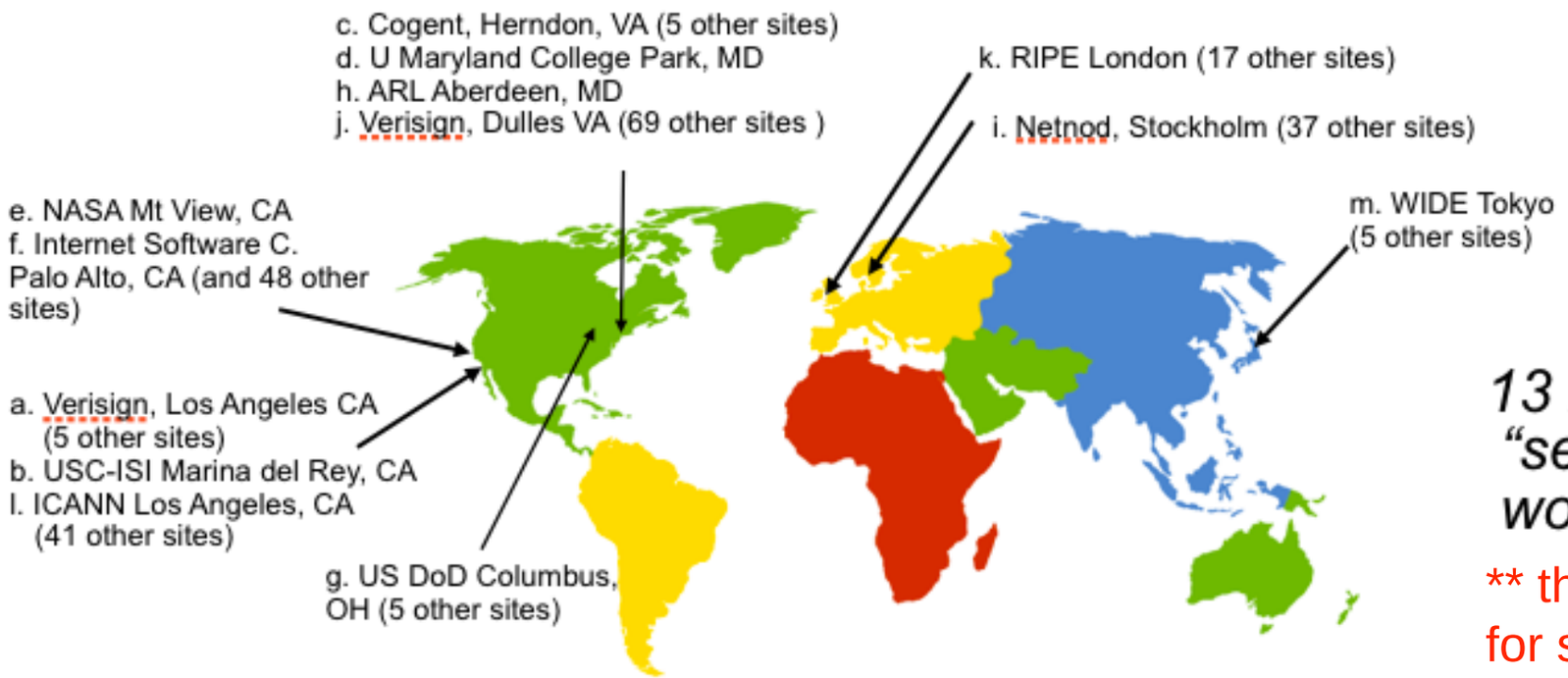
DNS: A Distributed, Hierarchical Database



- **Client wants IP for www.amazon.com**
  - 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

Root DNS 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" worldwide

** though they are replicated for security and reliability

Top-Level Domain & Authoritative DNS 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)
  - Verisign maintains servers for .com TLD (and many others)
  - Educause maintains servers for .edu TLD

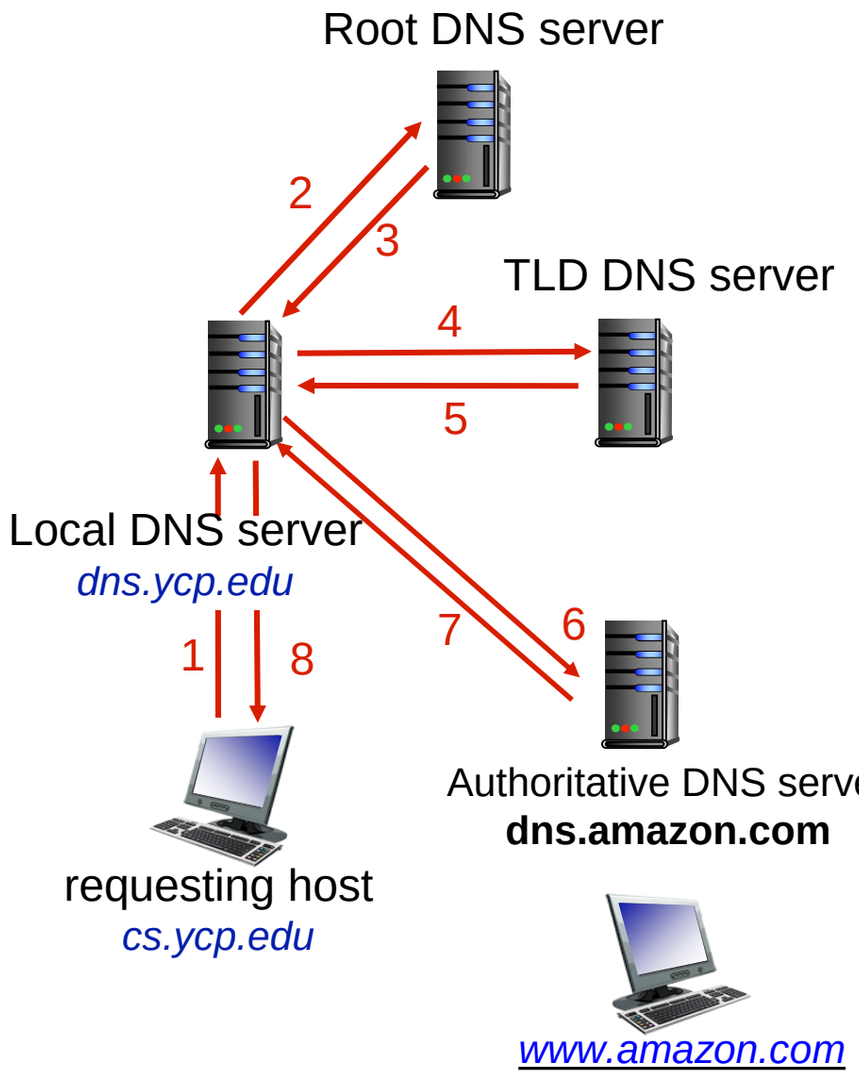
- **Authoritative DNS Servers**
  - Organization's own DNS server(s), providing authoritative hostname to IP mappings for organization's named hosts
  - Can be maintained by organization or service provider

Local DNS Name Server

- **Does not strictly belong to the DNS 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 cs.ycp.edu wants IP address for www.amazon.com**
- **Iterated query:**
  - Contacted server replies with name/address of server to contact
  - "I don't know this name, but ask this server"



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 a named host changes its IP address, may not be known Internet-wide until all TTLs expire

DNS Records

- **Resource Record (RR) format stored by DNS servers**
  - **`RR: (name, value, type, ttl)`**
- **Four different RR types**

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 mail server associated with **`name`**

DNS Message Format

- **Query and Reply messages, both use same message format**
  - Message Header
    - **Identification**: 16 bit # for query, reply includes same #
    - **Flags**:
      - Query or reply
      - Recursion desired
      - Recursion available
      - Reply is authoritative
- **Question section**: contains name and type fields for the query
- **Answer section**: contains RRs in response to a query
- **Authority section**: contains RR for authoritative servers

Identification	Flags
# Questions	# Answer RRs
# Authority RRs	# Additional RRs
Questions (variable # of questions)	
Answers (variable # of answers)	
Authority (variable # of RRs)	
Additional Info (variable # of RRs)	

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 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.networkuptopia.com; type MX record for networkutopia.com**

DNS Vulnerabilities

- **Distributed Denial of service attacks on name server**
  - Bombard root servers with traffic
    - Not successful to date
    - Root servers are protected by traffic filters
    - Local DNS servers cache IP addresses of TLD servers, allowing root server bypass
  - Bombard TLD servers
    - Potentially more dangerous
- **Redirect attacks**
  - Man-in-middle
    - Intercept queries and return bogus replies
  - DNS poisoning
    - Send bogus replies to DNS server which then caches that info