Lesson 2.2: Application Layer

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OUTLINE

- Domain Name System (DNS).
- DNS services.
- DNS operation.
- DNS caching.
- Resource records.
- Messages.

DNS: INTRO (1)

- **Domain Name System** (**DNS**) – directory **service** that **translates hostnames** (*latech.edu*) into **IP addresses** (*138.47.18.212*).
- DNS consists of two **parts**:
  - **Distributed database** implemented in a **hierarchy** of DNS servers.
  - **Application-layer protocol** that allows hosts to query distributed database.
- DNS **protocol** runs over **UDP** and uses **port 53**.

DNS: INTRO (2)

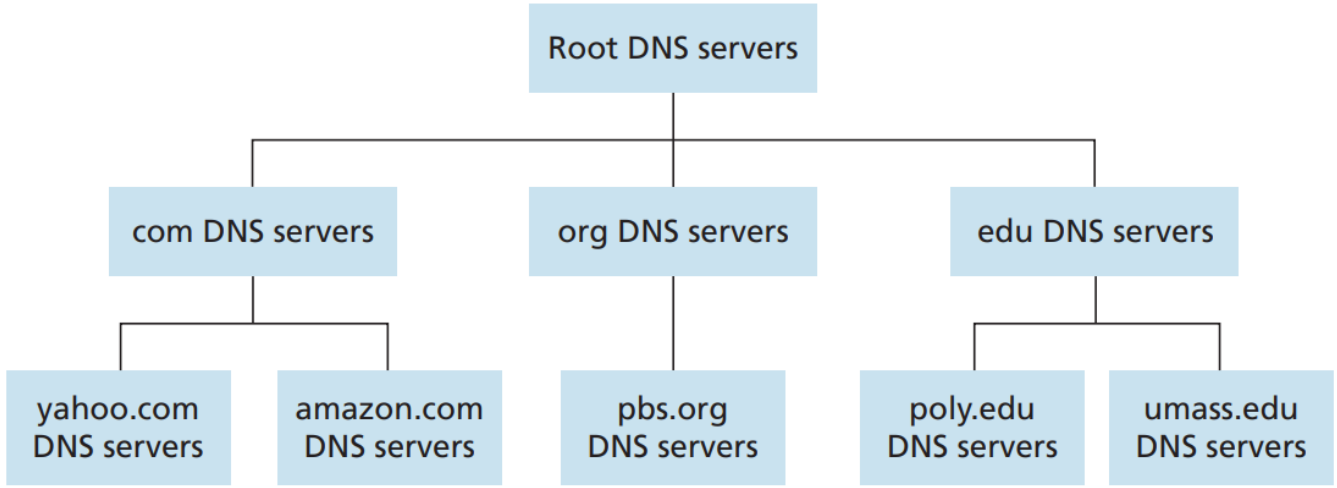
- DNS commonly **employed** by other **application-layer protocols**.
- **Example**:
  - For HTTP client to request *www.someschool.edu/index.html* it must obtain IP address of *www.someschool.edu* to send an HTTP request message.
    - HTTP client runs client side of DNS application.
    - Browser extracts hostname from URL and passes it to the client side of DNS.
    - DNS client sends a query containing hostname to a DNS server.
    - DNS client receives the reply with IP address of the hostname.
    - Once the browser receives the IP address it initiates TCP connection to the HTTP process at port 80 at that IP address.

DNS: SERVICES

- **Additional** DNS services:
  - **Host aliasing**.
    - Maps additional hostnames (alias) to canonical hostname.
  - **Mail server aliasing**.
    - Provides canonical hostname for supplied alias hostnames in mail applications.
  - **Load distribution**.
    - Distributes the load among replicated Web servers.
    - A set of IP addresses is associated with one canonical hostname.
    - IP addresses are rotated within each reply.

DNS: OPERATION (1)

- DNS is implemented as a **distributed hierarchical database**.
  - **Centralized design** would not **scale** to the needs of modern Internet.
    - Single point of failure.
    - Traffic volume.
    - Distant centralized database.
    - Maintenance.
- Three* **classes** of DNS servers:
  - **Root** DNS servers.
  - **Top-level domain** (**TLD**) DNS servers.
  - **Authoritative** DNS servers.
  - ***Local** DNS servers.



Portion of the DNS servers hierarchy

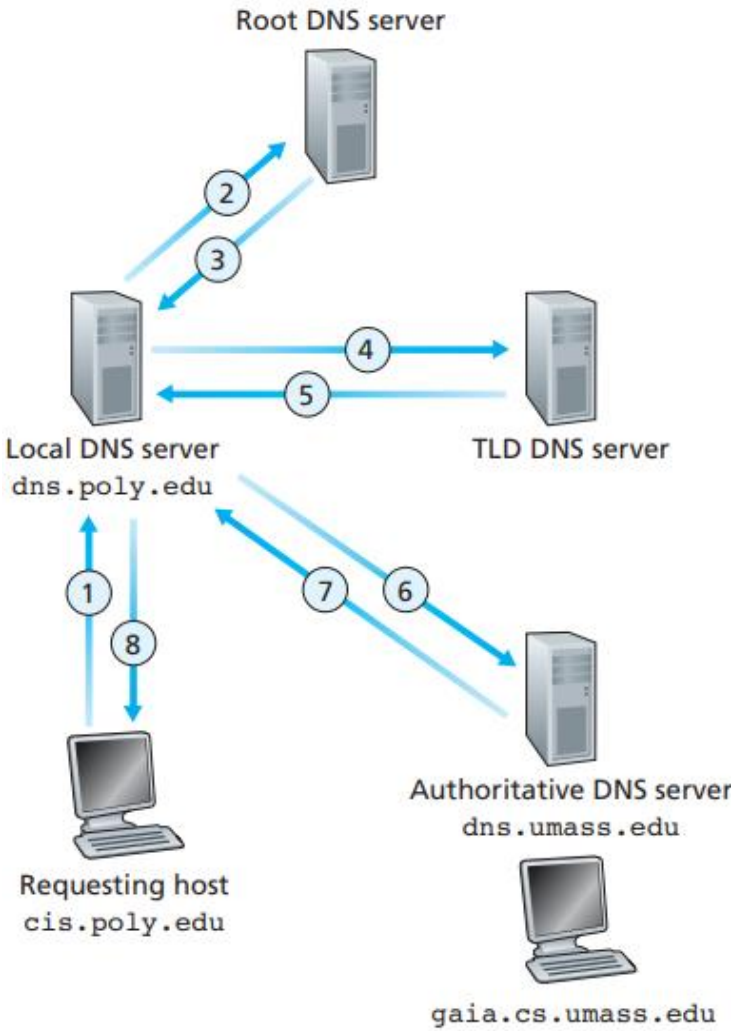
DNS: OPERATION (2)

- Three+ **classes** of DNS servers:
  - **Root** DNS servers.
    - 13 root DNS servers (A-M).
    - Each server is a network of replicated servers (security and reliability).
  - **Top-level domain** (**TLD**) DNS servers.
    - Responsible for top-level domains (com, org, net, edu, gov, country top-level).
  - **Authoritative** DNS serves.
    - Organization's own DNS servers that provide authoritative hostname to IP mappings for organization's named hosts.
  - **Local** DNS servers.
    - Technically, not a part of the hierarchy.
    - Have local cache of recent name-to-address translation pairs.
    - Acts as proxy, forwards query into hierarchy.

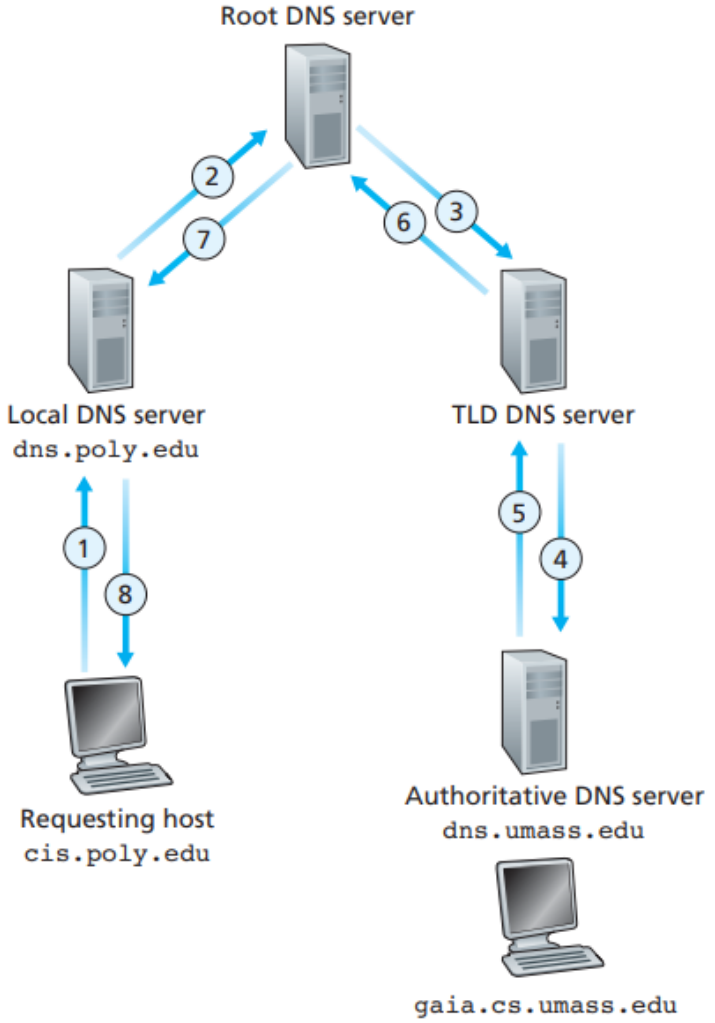
DNS: OPERATION (3)

- **Example**:
  - Host at *cis.poly.edu* wants to get IP address for *gaia.cs.umass.edu*.

- Two **approaches**:
  - **Iterated query**.
    - Contacted server replies with name of server to contact.
  - **Recursive query**.
    - Puts burden of name resolution on contacted name server.



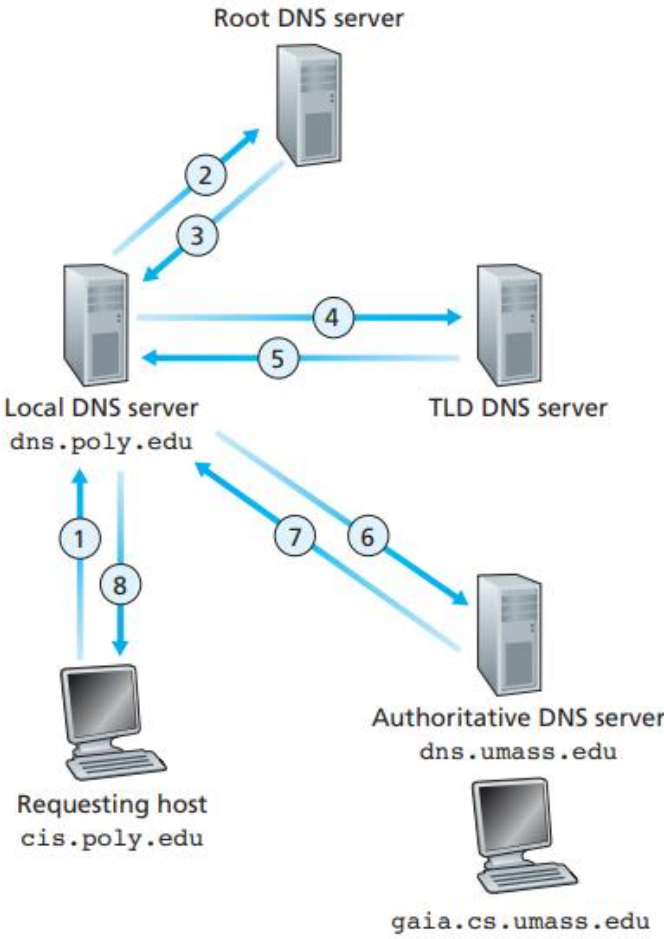
Iterated DNS queries



Recursive DNS queries

DNS: CACHING

- Servers **cache hostname-address** mappings that they receive.
  - Cache entries **timeout** (*deleted*) after predefined time (**TTL**).
  - **TLD** servers typically **cached** in **local** servers.
    - **Root** servers are **less often** visited.
- **Cached** entries may be **out-of-date**.
  - **Change** of host IP address may not be known until its entry **expire**.
    - **Best effort** name-to-address translation.



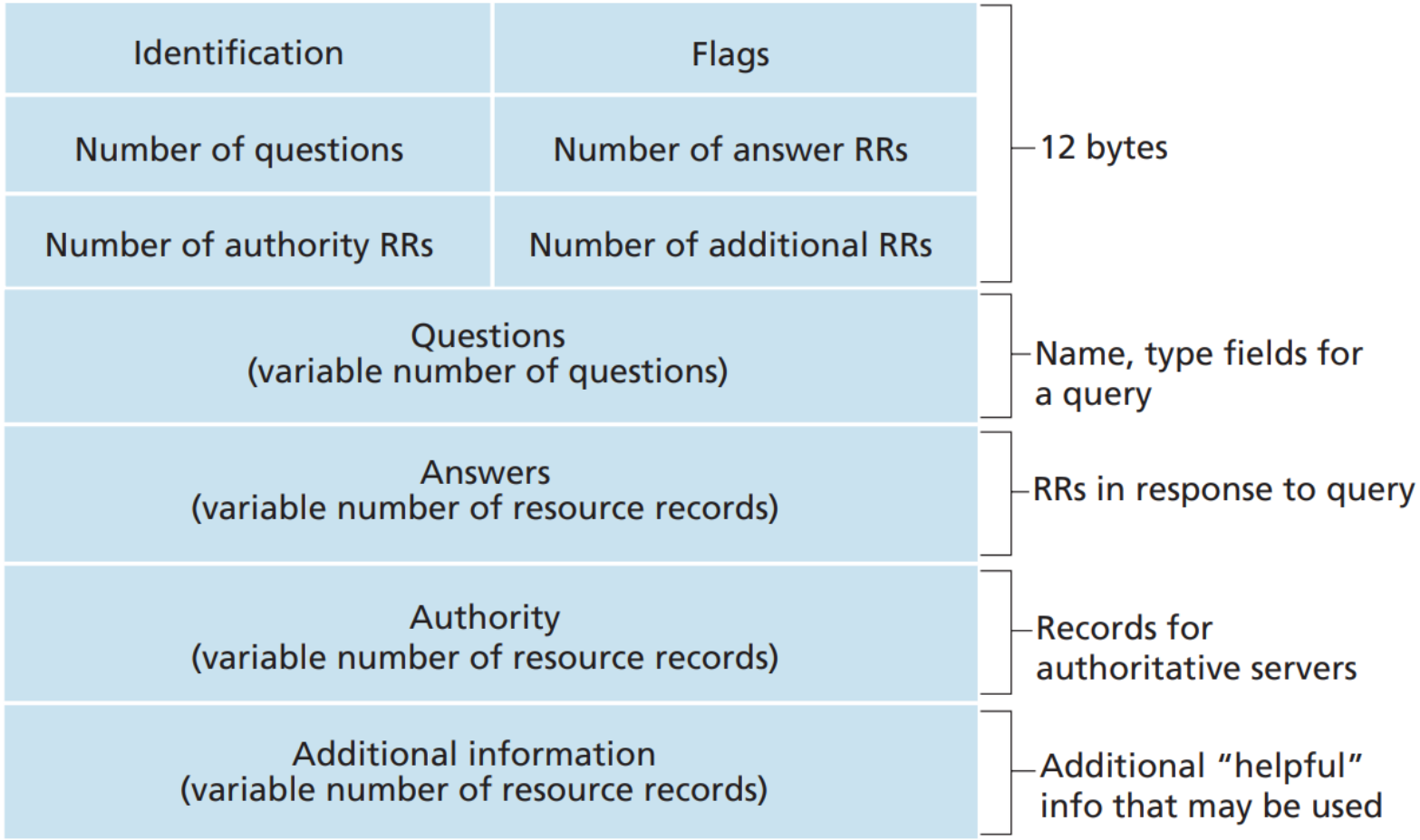
DNS caching

DNS: RESOURCE RECORDS

- DNS **distributed database** stores **resource records** (**RR**) that provide hostname-to-IP address **mapping**.
- **RR format**: *(Name, Value, Type, TTL).*
  - **Time to live *(TTL)*** determines when the resource should be **removed** from cache.
  - Meaning of ***Name*** and ***Value*** depends on ***Type***:
    - **Type=A**
      - **Name**=hostname, **Value**=IP address / *(relay1.bar.foo.com, 145.37.93.126, A)*
    - **Type=NS**
      - **Name**=domain name, **Value**=hostname (authoritative DNS server) / *(foo.com, dns.foo.com, NS)*
    - **Type=CNAME**
      - **Name**=hostname (alias), **Value**=hostname (canonical) / *(foo.com, relay1.bar.foo.com, CNAME)*
    - **Type=MX**
      - **Name**=hostname (alias), **Value**=name of mail server / *(foo.com, mail.bar.foo.com, MX)*

DNS: MESSAGES

- Two **types** of DNS messages: **query** and **reply**.
  - Both have the **same format**.



DNS message format

DNS: INSERTING NEW RECORDS

- **Example**: new startup “My Company”.
  - **Register** name *mycompany.com* at DNS registrar.
    - **Provide** names & IP addresses of **authoritative** name servers (primary and secondary).
      - *dns1.mycompany.com @ 212.212.212.1*
      - *dns2.mycompany.com @ 212.212.212.2*
  - Registrar **inserts** two **RRs** into .com TLD server.
    - *(mycompany.com, dns1.mycompany.com, NS)* & *(dns1.mycompany.com, 212.212.212.1, A)*
    - *(mycompany.com, dns2.mycompany.com, NS)* & *(dns2.mycompany.com, 212.212.212.2, A)*
  - **Create Type A** record for Web server *www.mycompany.com* in **authoritative** DNS servers.
    - *(www.mycompany.com, 212.212.71.4, A)*
  - **Create Type MX** record for mail server *mail.mycompany.com* in **authoritative** DNS servers.

SUMMARY

- DNS.
- DNS services.
- Classes of DNS servers.
- DNS caching.
- Resource records.
- DNS message format.