Domain Name System

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CS 3103: Compute Networks and Protocols

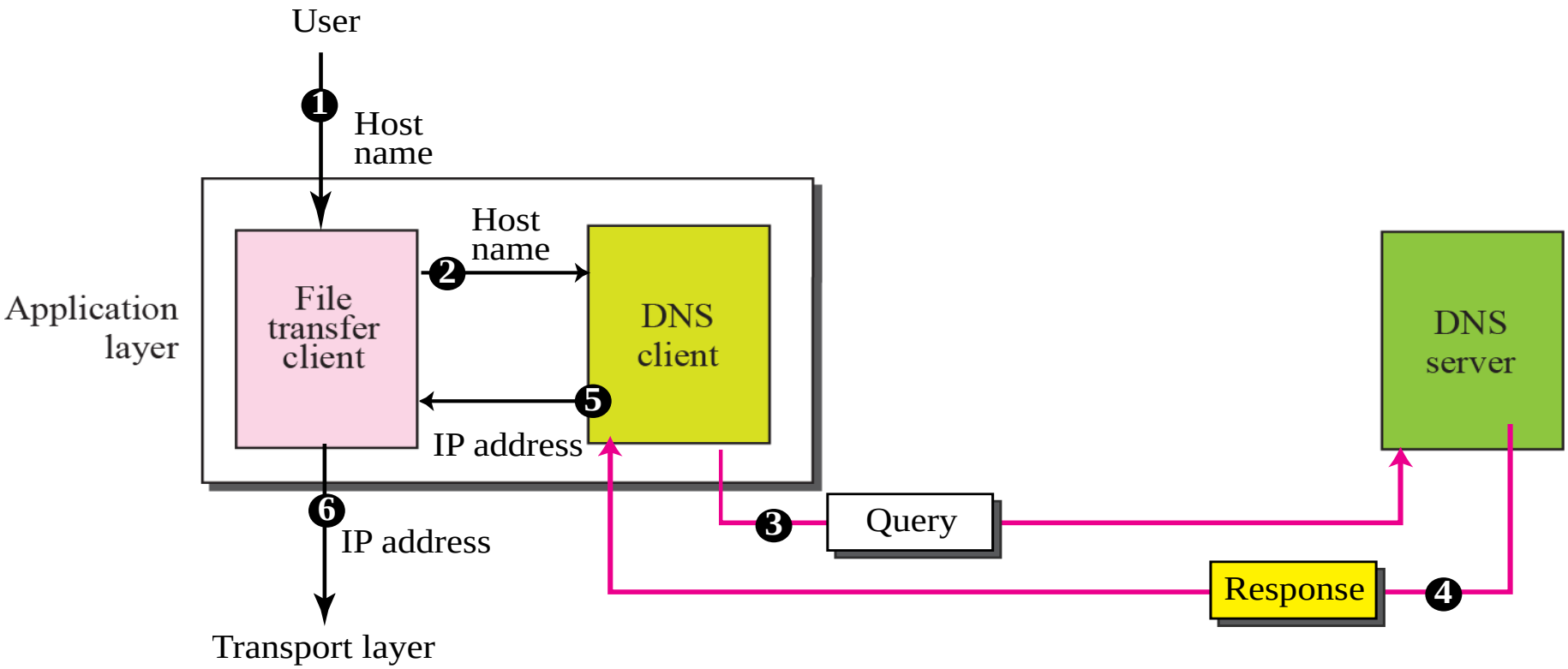
Names Vs. Addresses

- Names are easier for human to remember
  - www.comp.nus.edu.sg vs. 137.132.90.2
- Addresses can be changed without changing names
  - move www.comp.nus.edu.sg to 203.126.100.199
- Name could map to multiple addresses
  - google.com maps to multiple replicas of the Web site and to different "nearby" addresses in different geographies to reduce latency
- Multiple names could map to the same address

Domain Name System (DNS)

- The Domain Name System is
  - a distributed database implemented in a hierarchy of **DNS servers**, and
  - an application-layer protocol that allows hosts to query the distributed database.
- The DNS servers are often UNIX machines
  - running the Berkeley Internet Name Domain (BIND) software.
- The DNS protocol runs over UDP on port 53.
- Used by other application-layer protocols
  - E.g., HTTP, SMTP, and FTP

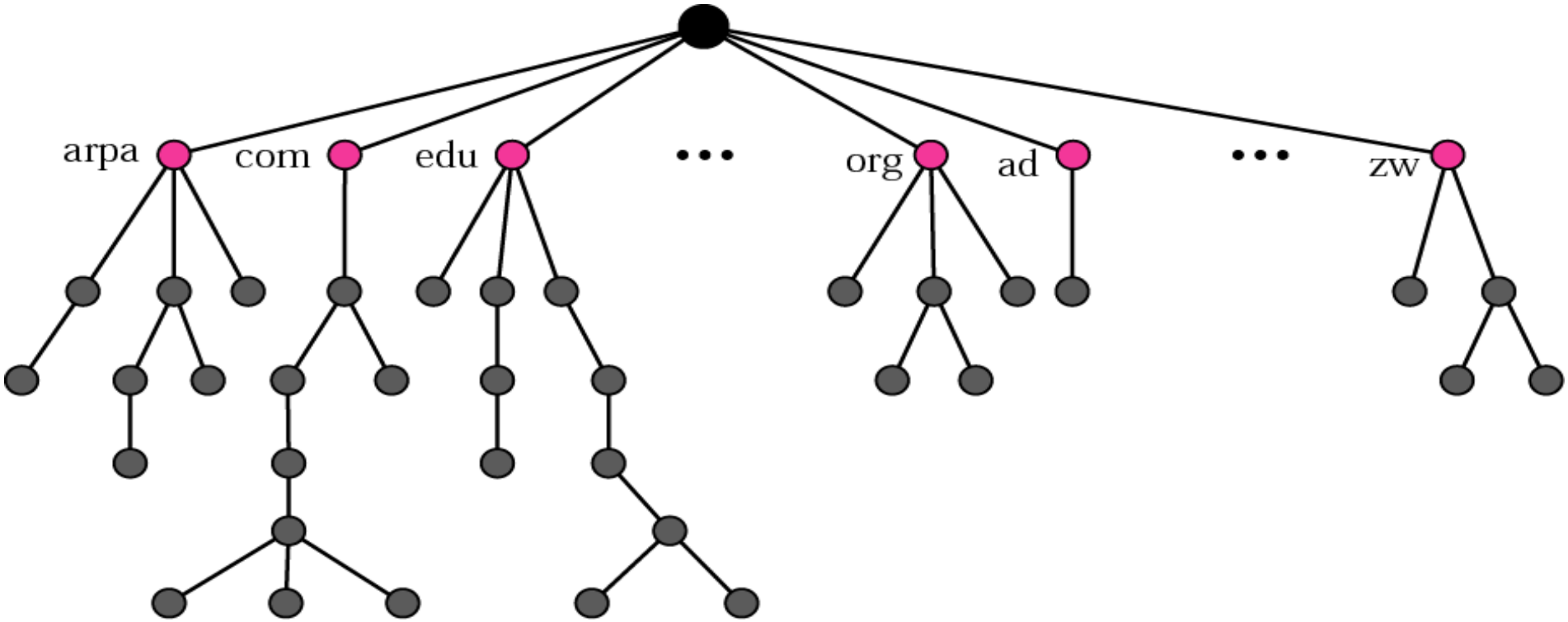
A Typical Scenario



DNS: Other Use Cases

- Host aliasing
  - Canonical hostname → alias hostname
  - E.g., webserver1.abc.com → www.abc.com
- Mail server aliasing
  - Bob's account with Hotmail → bob@hotmail.com
  - Web and mail servers share the same
- Load distribution
  - Load balancing among replicated servers
  - Rotate among the set of IP addresses in replies

Hierarchical Name Space



- Maximum 128 levels (level 0 to level 127)
- The label for each level is a string with maximum of 63 characters
- The root label is a null string

Hierarchical Name Space

- Name allocation decentralized to domains

  `host.sub-subdomain.. . ..subdomain.domain[.ROOT]`

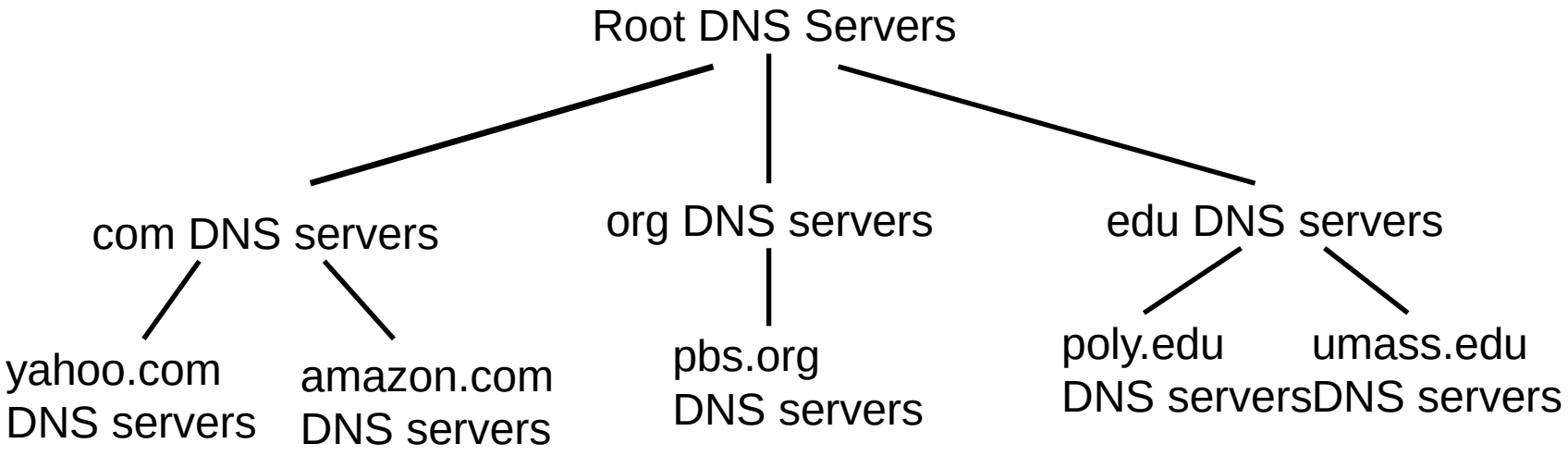
  `host:` machine name, can be an alias
  `sub-subdomain:` department (comp, eng, ceg, math)
  `subdomain:` institution, company, geography, provider
  `domain:` most significant segment (`edu, com, org, net, gov`)

- Domain: a sub-tree of the domain name space
- Domain name
  - Fully Qualified Domain Name (FQDN)
  - Partially Qualified Domain Name (PQDN)

Implementation

- *Distributed database* implemented in hierarchy of many *name servers*
  - A distributed database storing resource records (RR)
  - Client-server query-reply
- Host, routers and name servers communicate to *resolve* domain names
  - core Internet function, implemented as application-layer protocol
  - complexity at network's "edge"

Distributed, Hierarchical Database



client wants IP for www.amazon.com; 1st approx:

- client queries a 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

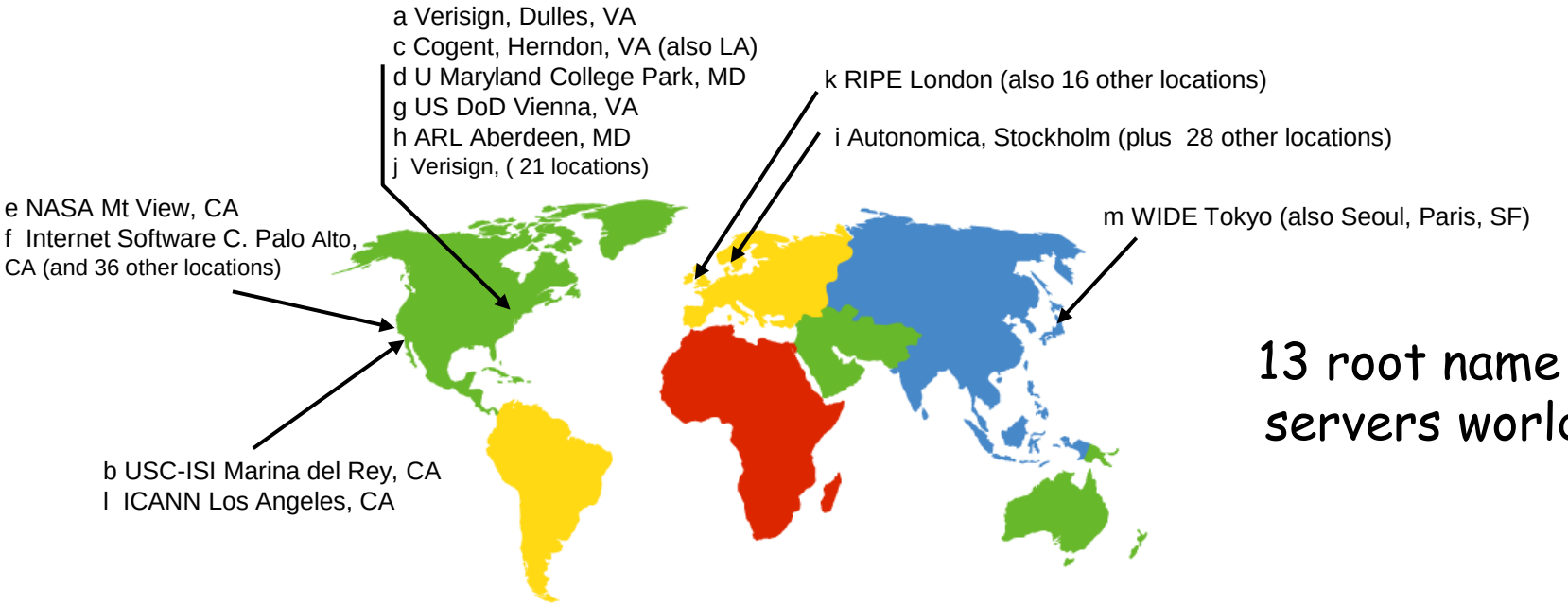
Discussion: Design Choices

- Why not flat name space?
- Why not centralize DNS?
  - Single point of failure
  - Traffic volume
  - Distant centralized database
  - Maintenance

Scalability!!

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 worldwide

TLD and 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
- Network Solutions maintains servers for com TLD
- Educause for edu TLD

Authoritative DNS servers:

- organization's DNS servers, providing authoritative hostname to IP mappings for organization's servers (e.g., Web, mail).
- can be maintained by organization or service provider

Local Name Server

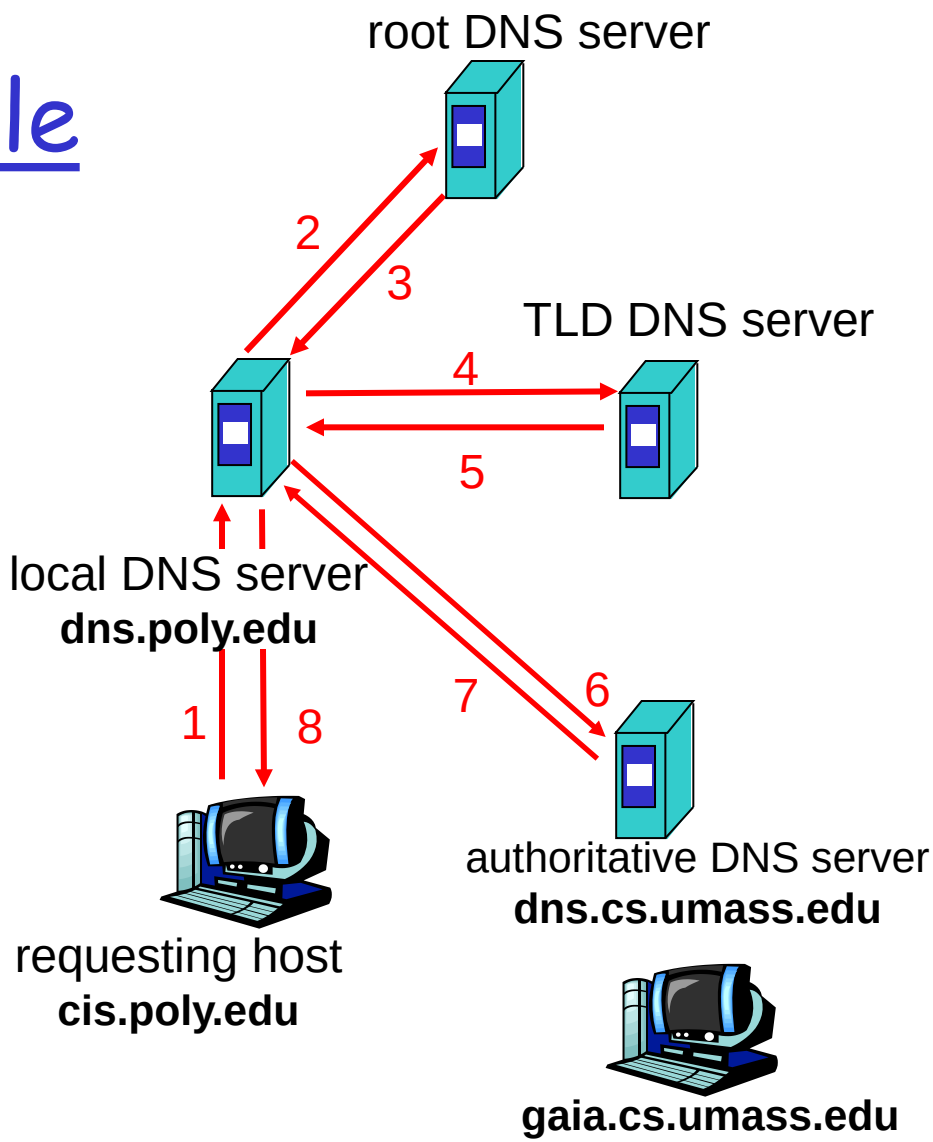
- Does not strictly belong to hierarchy
  - Like a "client" (the hierarchy is the "server")
- Each ISP (residential ISP, company, university) has one
  - also called "default name server"
- When host makes DNS query, query is sent to its local DNS server
  - acts as proxy, forwards query into hierarchy

DNS name resolution example

- Host at cis.poly.edu wants IP address for gaia.cs.umass.edu

iterated query:

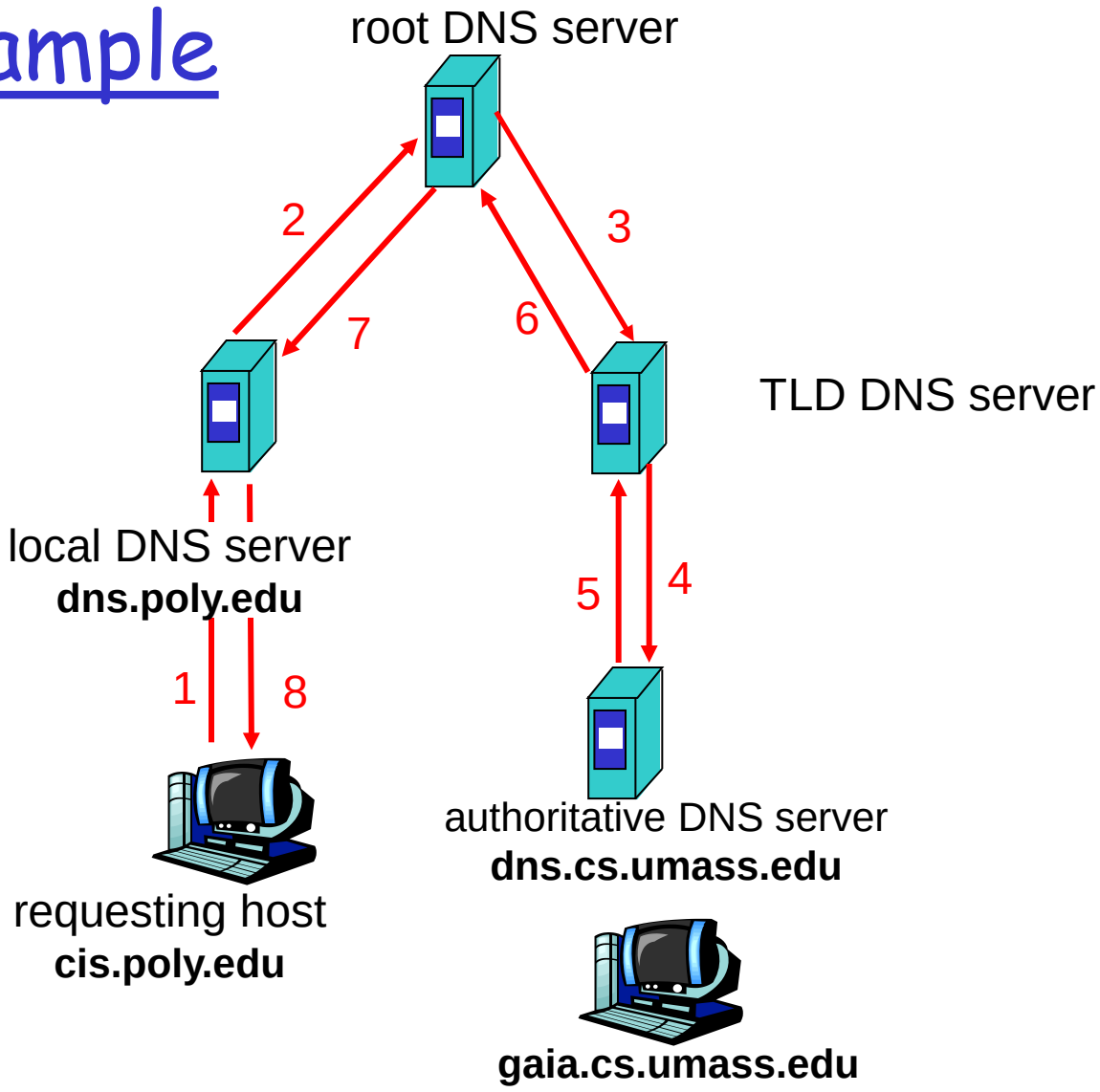
- contacted server replies with name of server to contact
- "I don't know this name, but ask this server"



DNS name resolution example

recursive query:

- puts burden of name resolution on contacted name server
- heavy load?



DNS: caching and updating records

- Once (any) name server learns mapping, it *caches* the mapping
  - cache entries timeout (disappear) after some time
  - TLD servers typically cached in local name servers
    - Thus root name servers not often visited
- 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 (Address)

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

Type=NS (Name Server)

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

Type=CNAME (Canonical NAME)

- **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 (Mail eXchange)

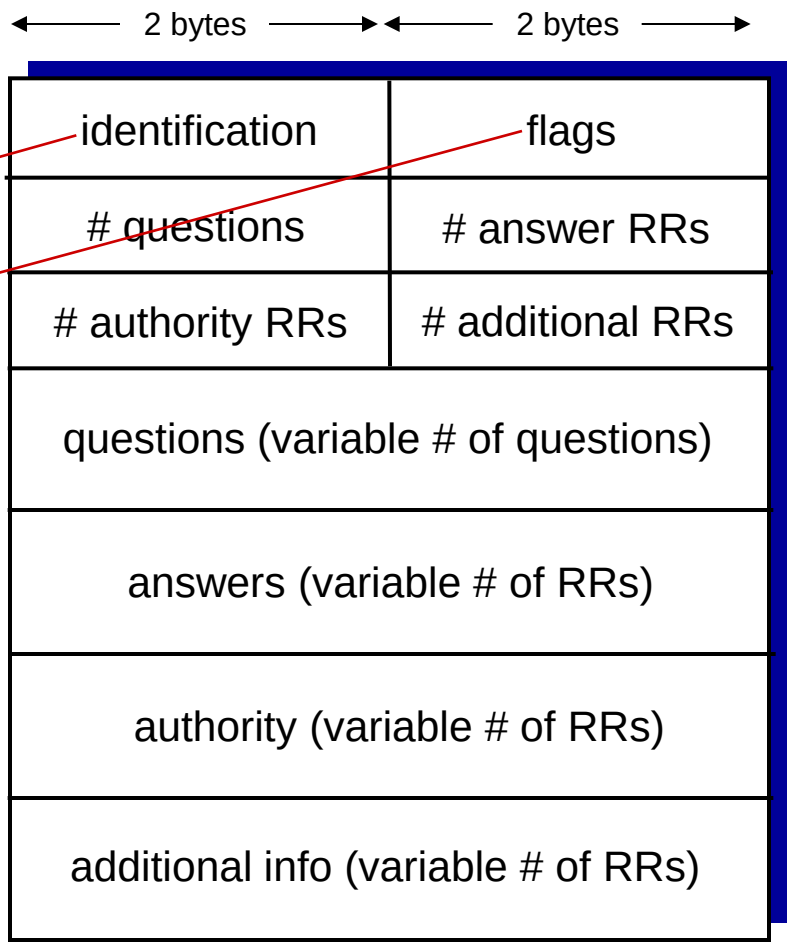
- **value** is name of mailserver associated with **name**

DNS protocol, messages

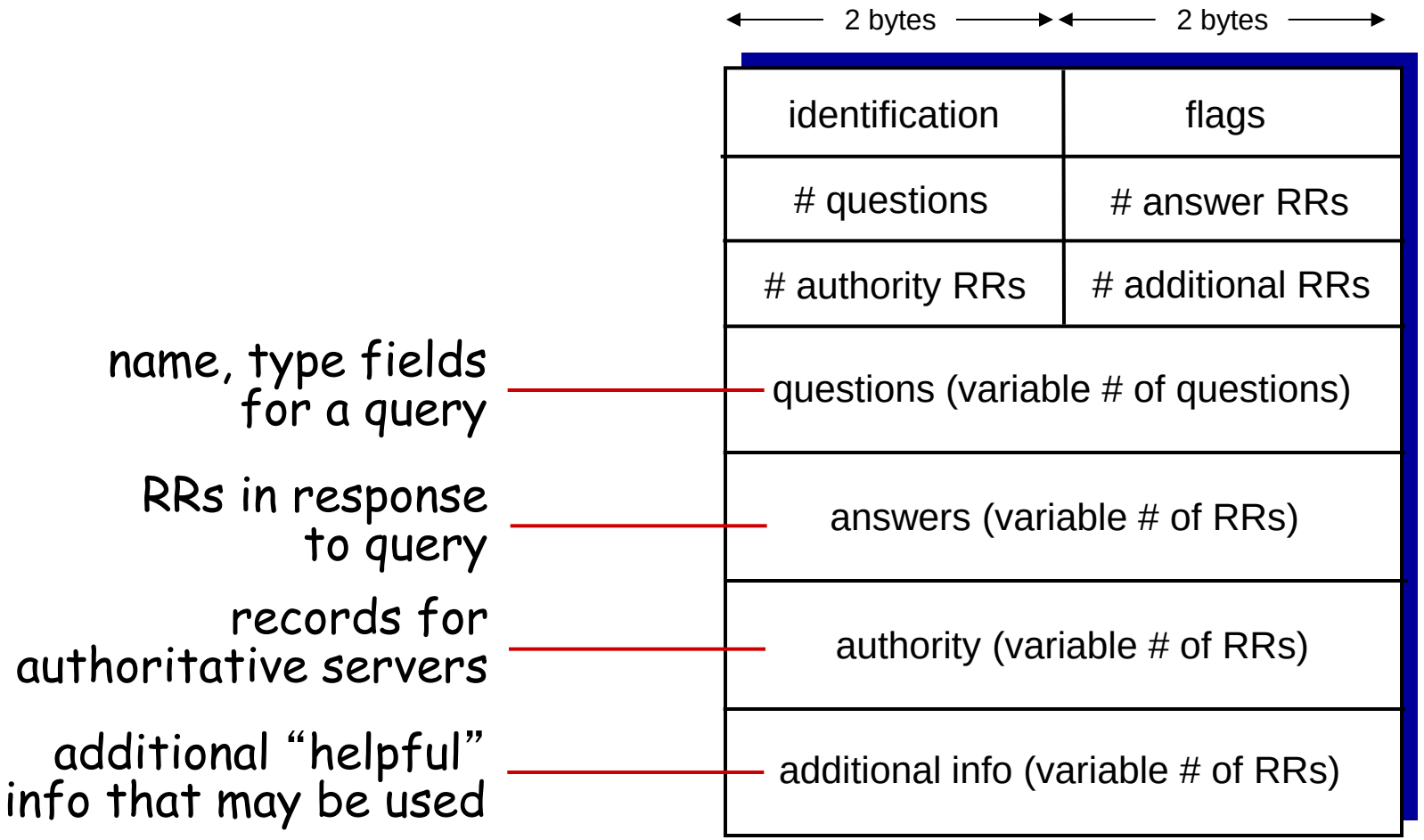
- *query* and *reply* messages, both with same *message format*

msg header

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



DNS protocol, messages



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
- How do people get IP address of your Web site?