CS348: Computer Networks

DNS

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DNS - Internet's Directory Service

- Just as humans can be identified in many ways, so too can Internet hosts. Two ways:
  - Hostname (e.g., gmail.co.in, iitg.ac.in)
    - these are mnemonic,
    - user friendly for Humans
  - IP Address (e.g., 121.7.106.83, 172.17.0.10)
    - these are structured numeric digits,
    - user friendly for Routers
- The Internet needs to have a **directory system** that can map a name to an address.
- The Internet is so huge today, a central directory system cannot hold all the mapping.
- A better solution - distribute the directory information among many computers in the world.
- This method is used by the **Domain Name System (DNS)**.

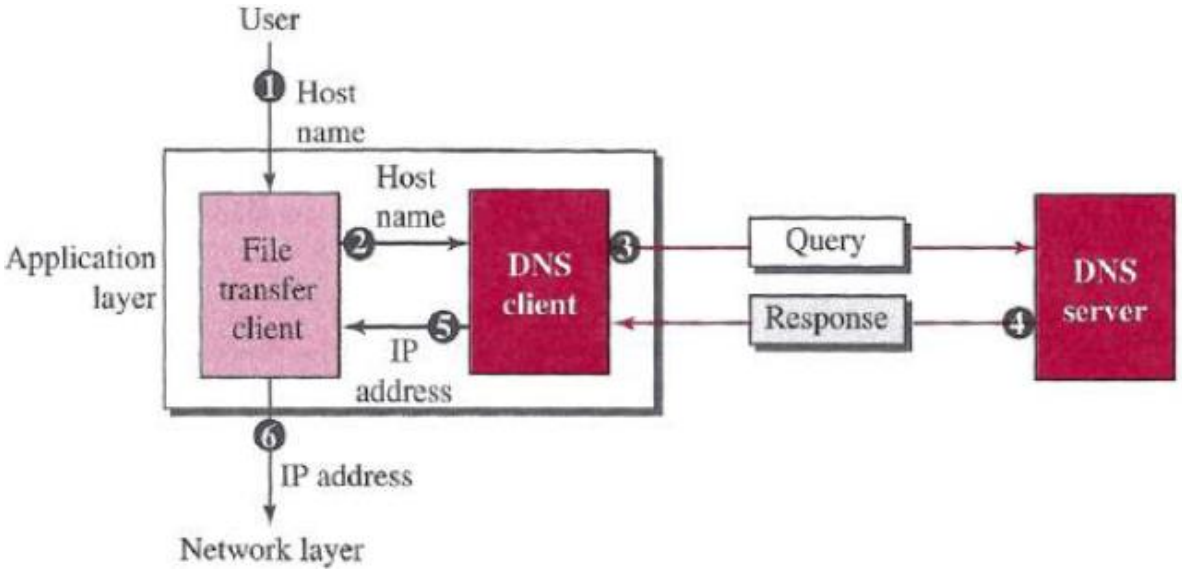
Cont…

- The DNS is a combination of :
  - a distributed database implemented in a hierarchy of **DNS servers**, and
  - an application-layer protocol that **allows hosts to query** the distributed database

- Let the purpose of accessing the Internet is to make a connection between the file transfer client and server,
- but before this can happen, another connection needs to be made between the DNS client and DNS server

- DNS protocol runs over UDP and uses port 53.

- The DNS servers are often UNIX machines running the Berkeley Internet Name Domain (BIND) software



Design for DNS

- Design for DNS:
  - Centralized / Distributed

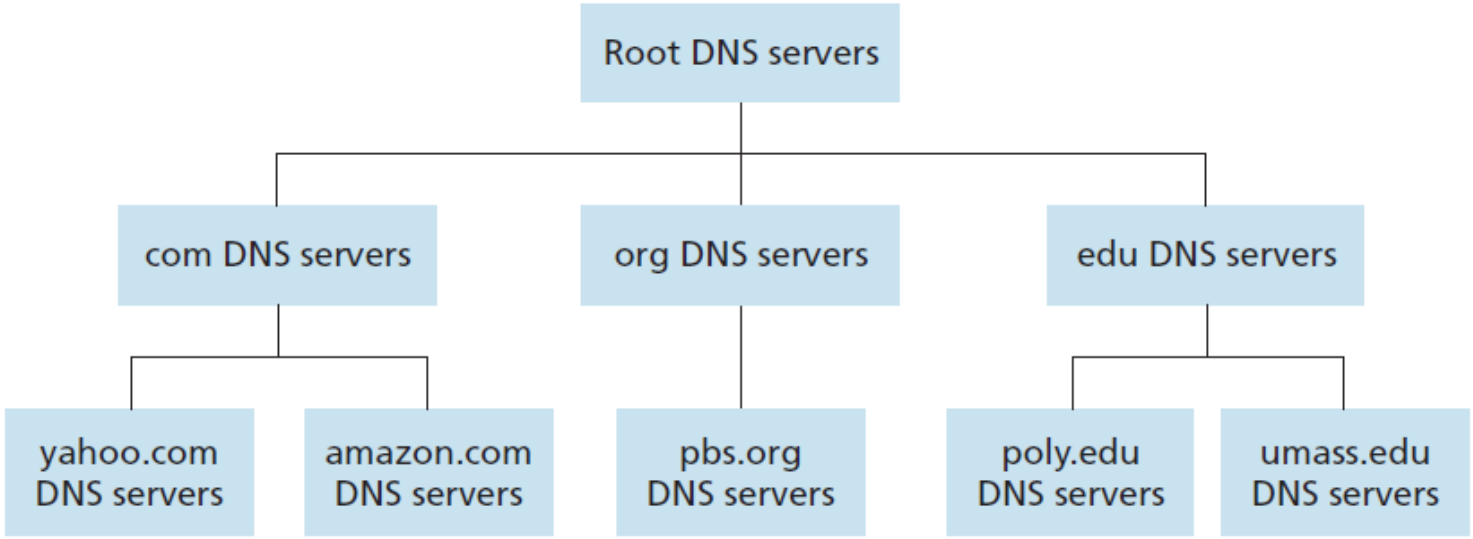
- The problems with a centralized design include:
  - A single point of failure: DNS server crashes, so does the entire Internet!
  - Traffic volume: A single DNS server would have to handle all DNS queries generated from hundreds of millions of hosts
  - Distant database: A single DNS server cannot be “close to” all the querying clients.
  - Maintenance: The single DNS server would have to keep records for all Internet hosts. Management of it becomes very difficult!

DNS Services

- Fundamental service : a directory service that translates hostnames to IP addresses.

- provides a few other important services :
  - Host aliasing: relay1.west-coast.enterprise.com could have, say, two aliases such as enterprise.com and www.enterprise.com
  - Mail server aliasing: the canonical hostname of the Hotmail server might be something like relay1.west-coast.hotmail.com but the mail server is simply hotmail.com
  - Load distribution: used to perform load distribution among replicated servers. For replicated servers, a set of IP addresses is thus associated with one canonical hostname.

Hierarchy of DNS servers



- the mappings for all of the hosts in the Internet are distributed across the DNS servers

- three classes of DNS servers
  - root DNS servers (until 2012, Internet has 13 root DNS servers)
  - top-level domain (TLD) DNS servers
  - authoritative DNS servers (large university or organization may have it)

  - local DNS server : Each ISP has one or more local DNS

Cont…

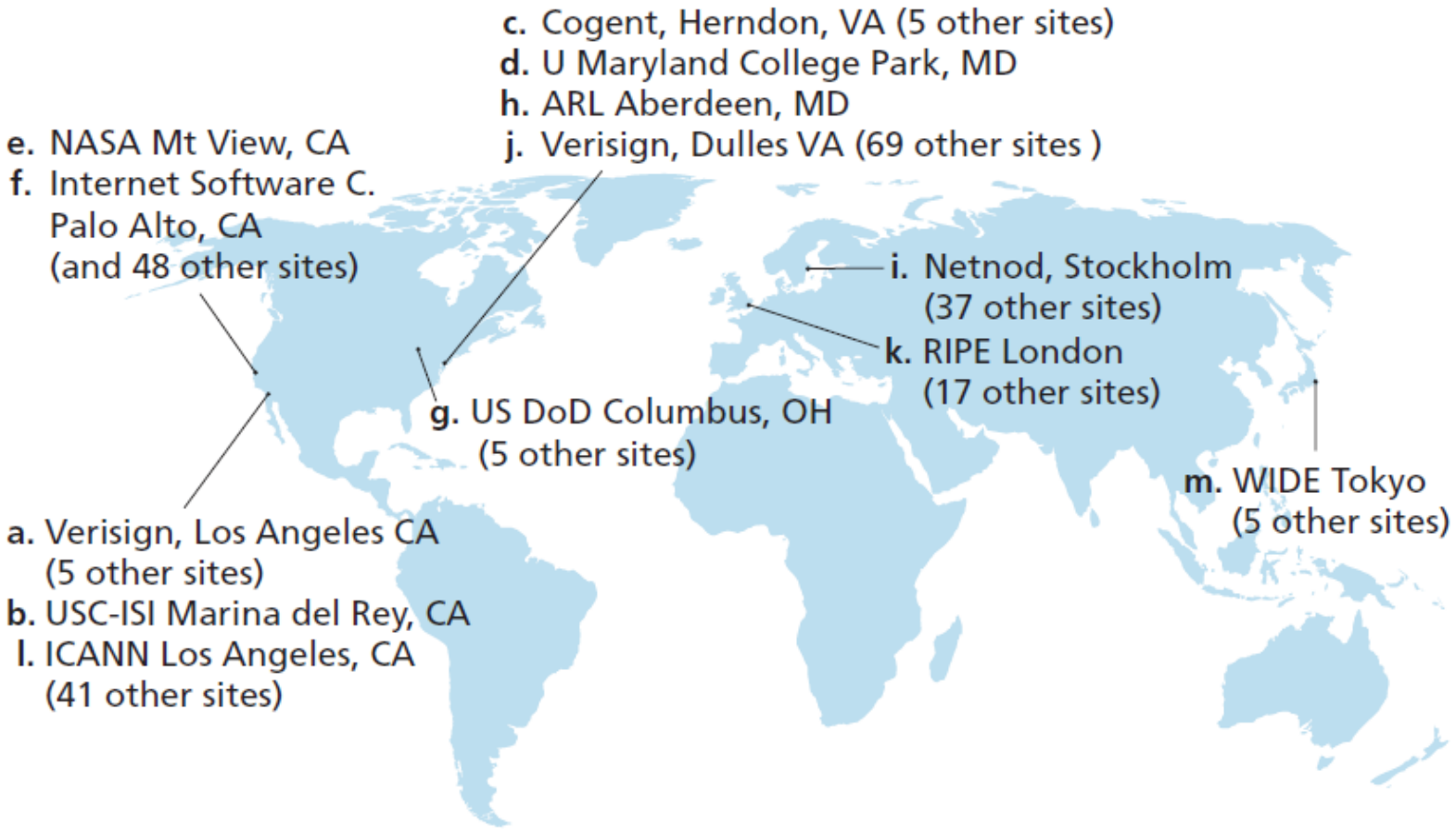
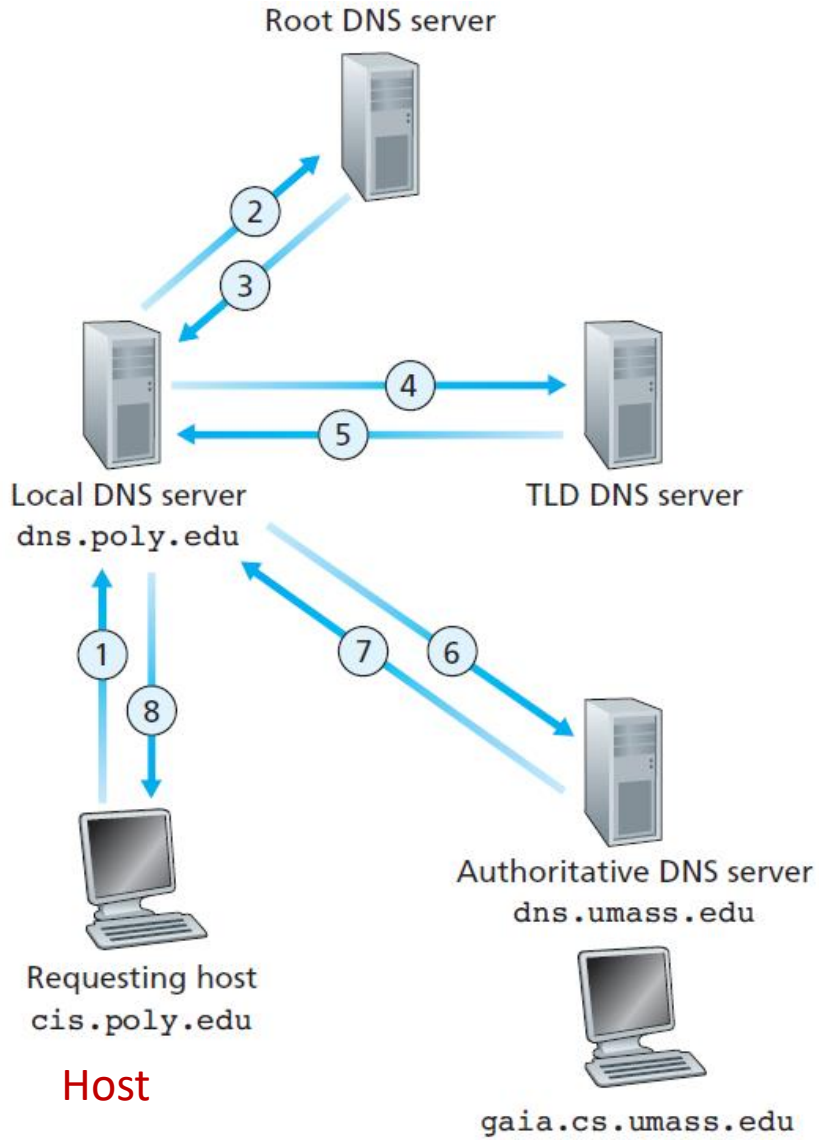


Figure 2.20 ♦ DNS root servers in 2012 (name, organization, location)

Interaction among DNS servers



- Let the **host** cis.poly.edu desires the IP address of gaia.cs.umass.edu.
- Let the Polytechnic's local DNS server is called dns.poly.edu
- Let an authoritative DNS server for gaia.cs.umass.edu is called dns.umass.edu.

1) The host first sends a DNS query message to its local DNS server.
2) The local DNS server forwards the query message to a root DNS server.
3) The root DNS server takes note of the edu suffix and returns a list of IP addresses for TLD servers responsible for edu.
4) The local DNS server then resends the query to one of these TLD servers.
5) The TLD server responds with the IP address of the authoritative DNS server
6) Finally, the local DNS server resends the query message directly to the authoritative DNS server

Name Space

- the names must be unique because the addresses are unique.

- A name space that maps each address to a unique name can be organized in two ways:
  - flat
  - hierarchical

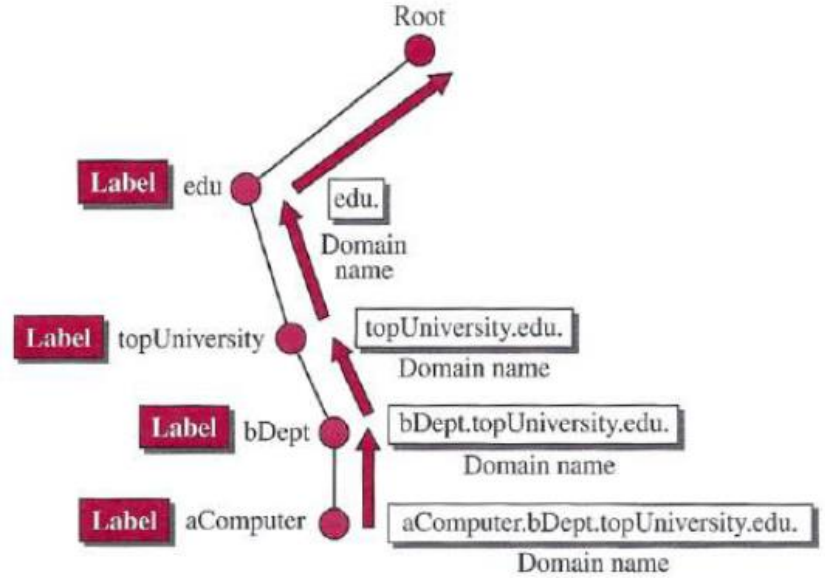
- *flat name space*
  - a name is assigned to an address
  - a name is a sequence of characters without structure
  - The names may or may not have a common section

  - Disadvantage: it cannot be used in a large system such as the Internet because it must be centrally controlled to avoid ambiguity and duplication

Cont…

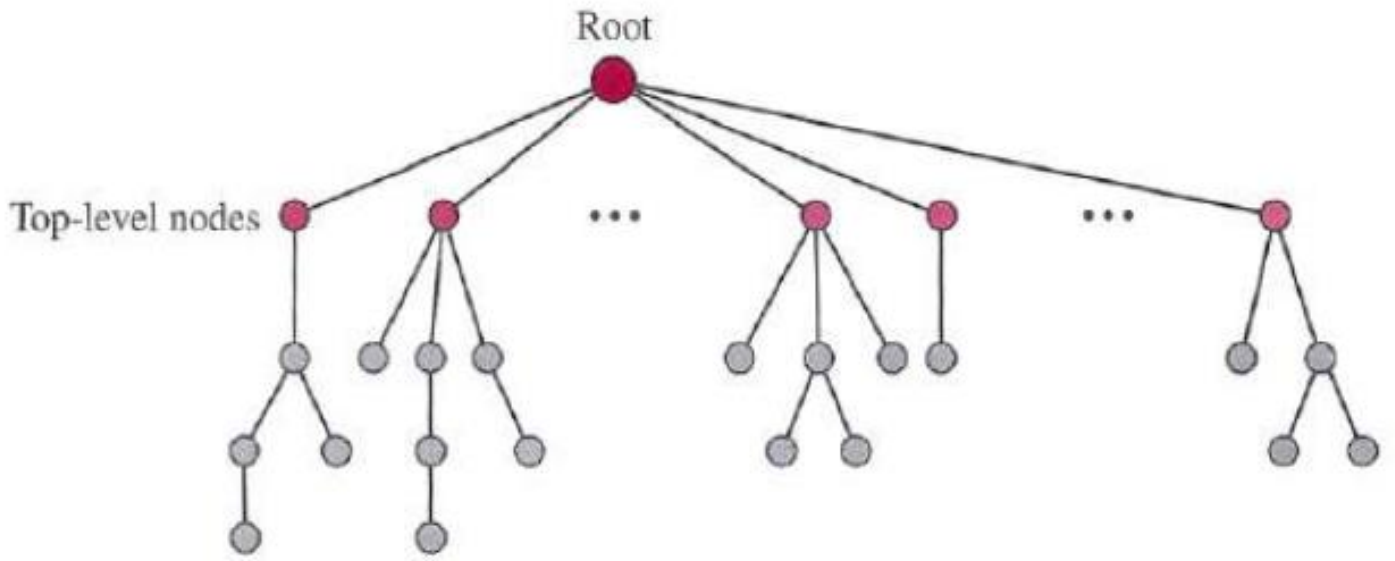
- *hierarchical name space:* each name is made of several parts
  - the first part can define the nature of the organization
  - the second part can define the name of an organization
  - the third part can define departments in the organization

- *Advantages*
  - the authority to assign and control the name spaces can be decentralized.
  - A central authority can assign the part of the name. E.g, name & nature of the organization Rest of the name can be assigned by the organization itself



Domain Name Space

- the names are defined in an inverted-tree structure with the root at the top.



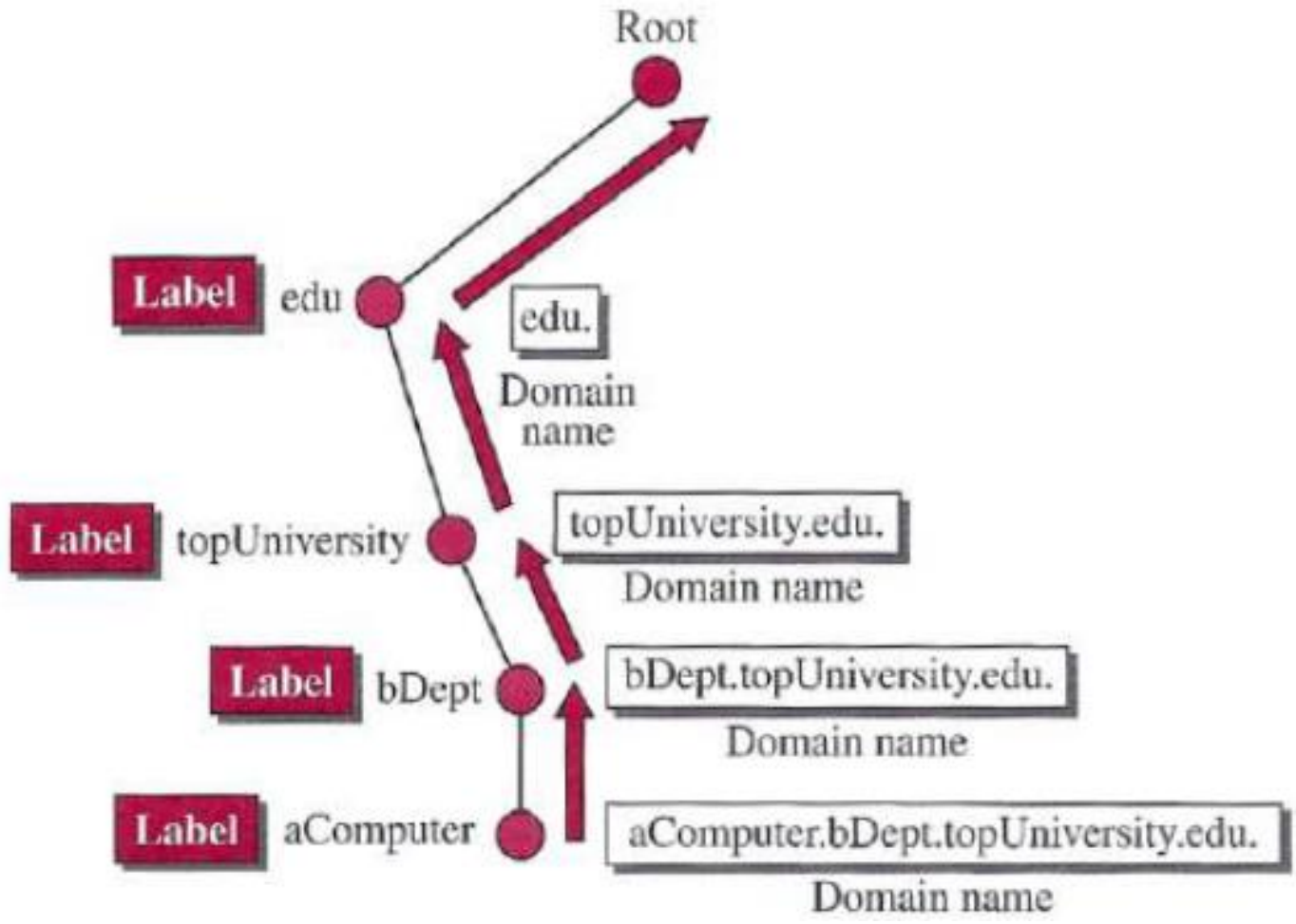
Cont…

- *Label:*
  - Each node in the tree has a label, which is a string with a maximum of 63 characters.
  - The root label is a null string (empty string).

- *Domain Name:*
  - Each node in the tree has a domain name.
  - A full domain name is a sequence of labels separated by dots (.)
  - The domain names are always read from the node up to the root.
  - The last label is the label of the root (null).

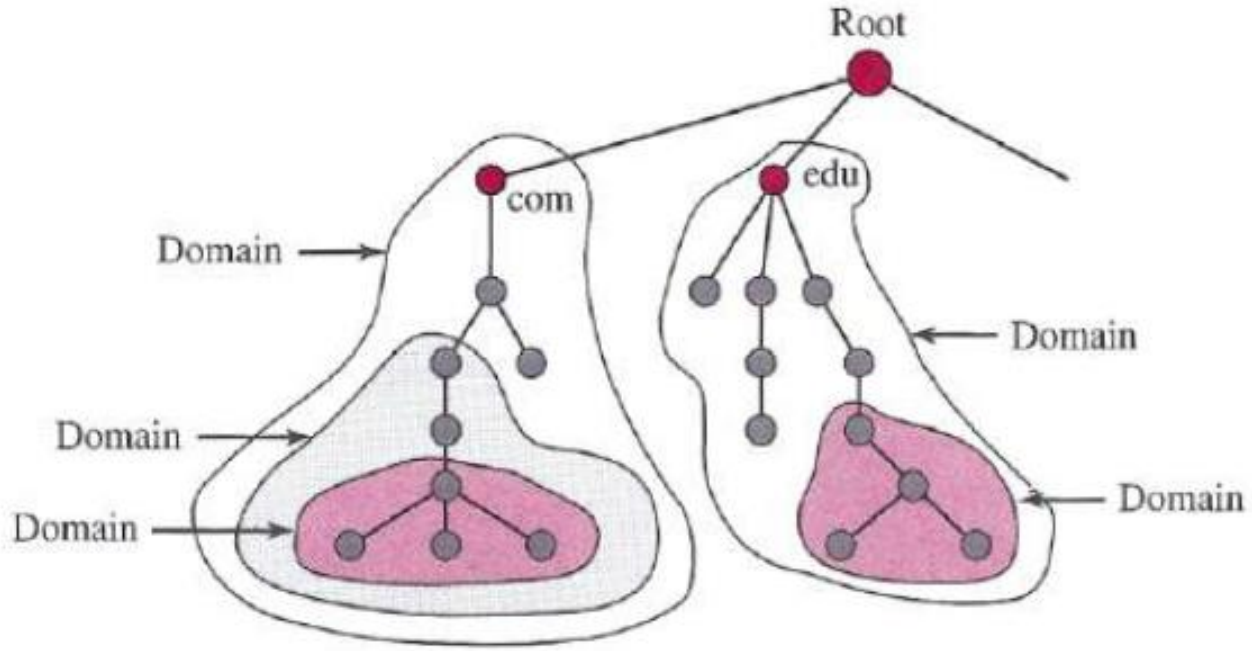
- Fully qualified domain name (FQDN):
  - If a label is terminated by a null string.
  - Else, it is Partially qualified domain name (PQDN)

Cont…


Root
Label
edu
edu.
Domain name
Label
topUniversity
topUniversity.edu.
Domain name
Label
bDept
bDept.topUniversity.edu.
Domain name
Label
aComputer
aComputer.bDept.topUniversity.edu.
Domain name

Domain

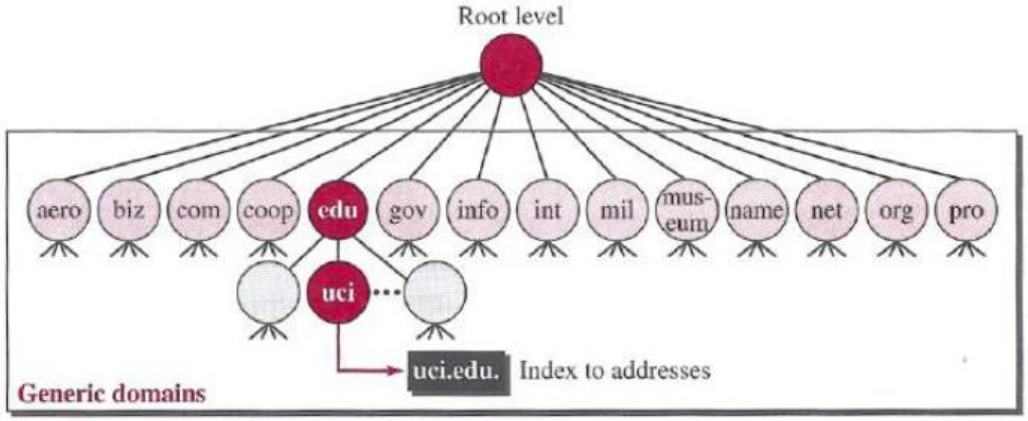
- A domain is a subtree of the domain name space

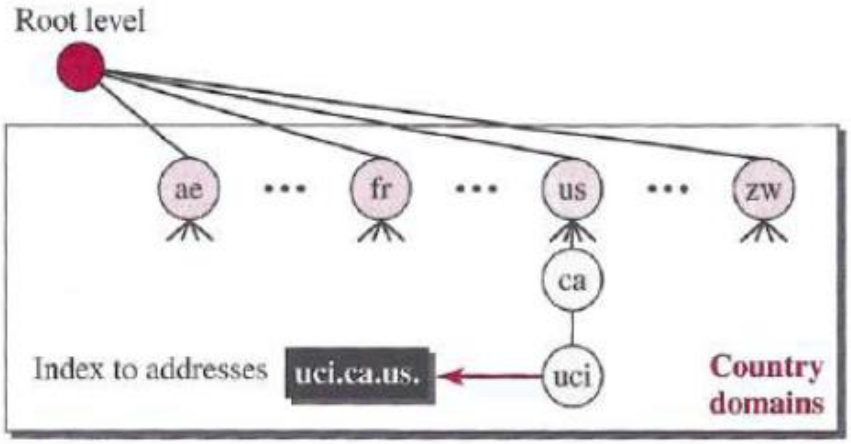


DNS in the Internet

- DNS is a protocol that can be used in different platforms.

- the domain name space (tree) is designed by many different ways:
  - generic domains
  - country domains

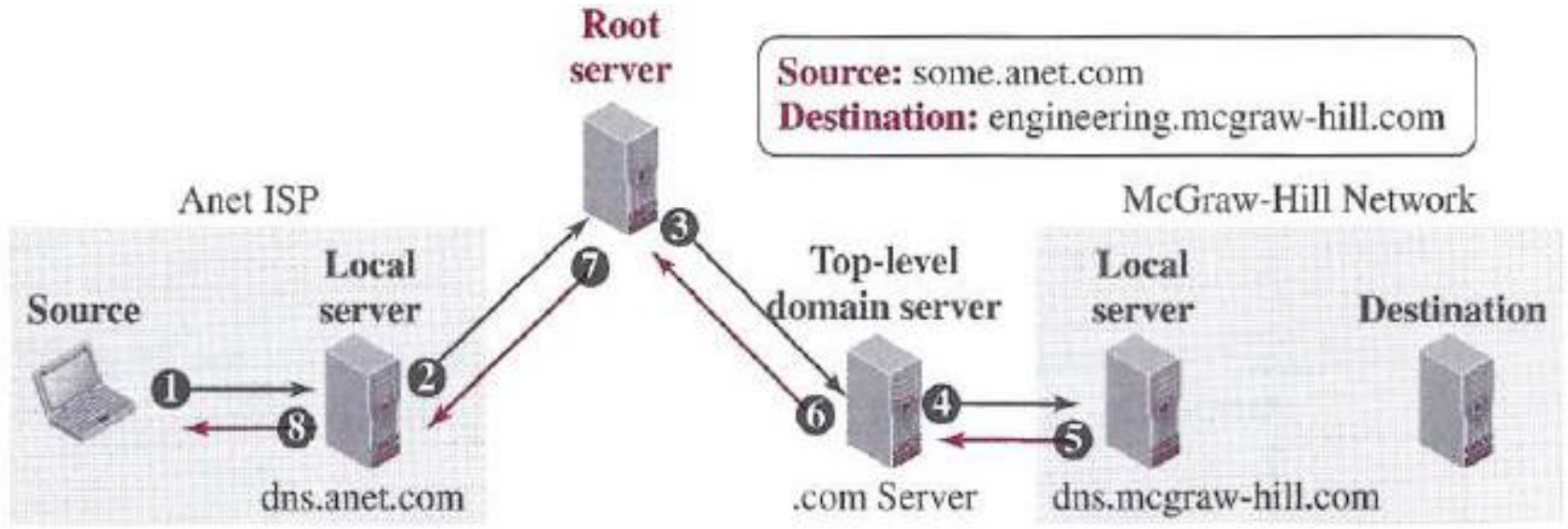




- E.g, The address *uci.ca.us.* can be translated to University of California, Irvine, in the state of California in the United States.

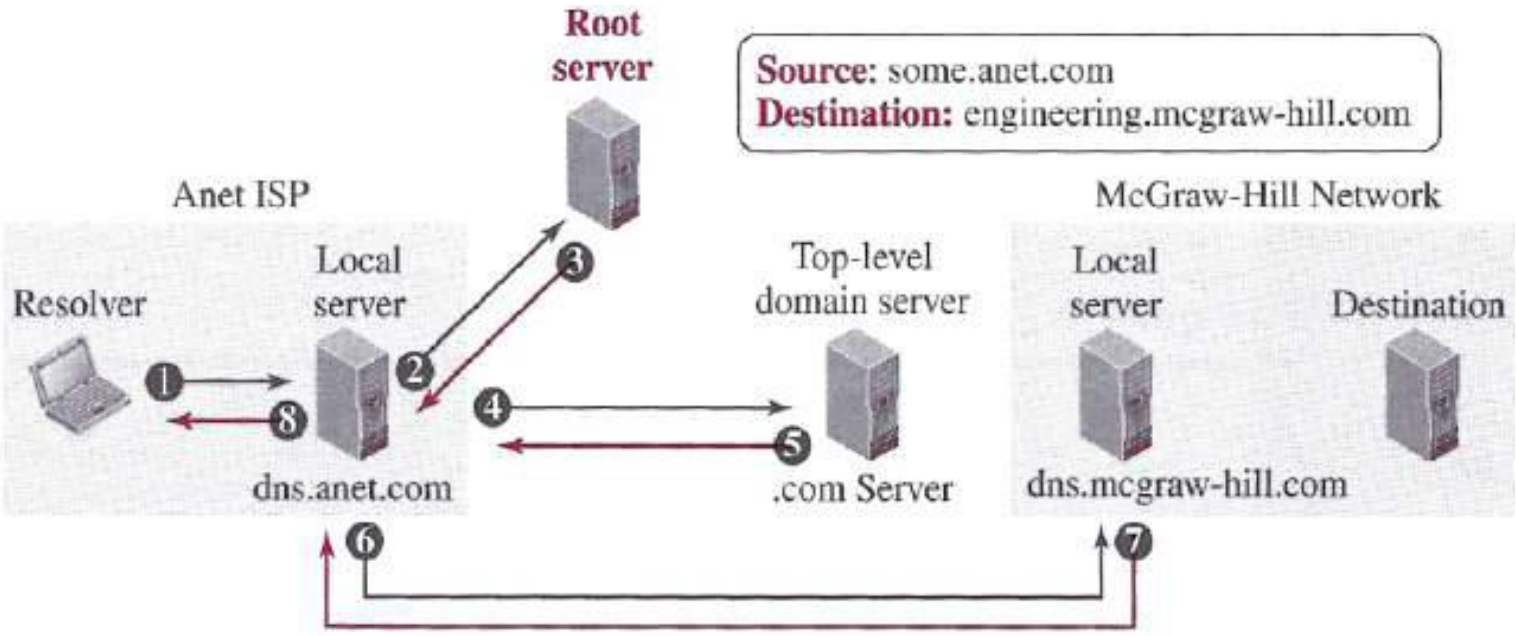
Name-Address Resolution

- Mapping a name to an address is called *name-address resolution*
- DNS is designed as a **client-server application**.
- A resolution process can be
  - Recursive
  - Iterative



Cont…

- Iterative Resolution:

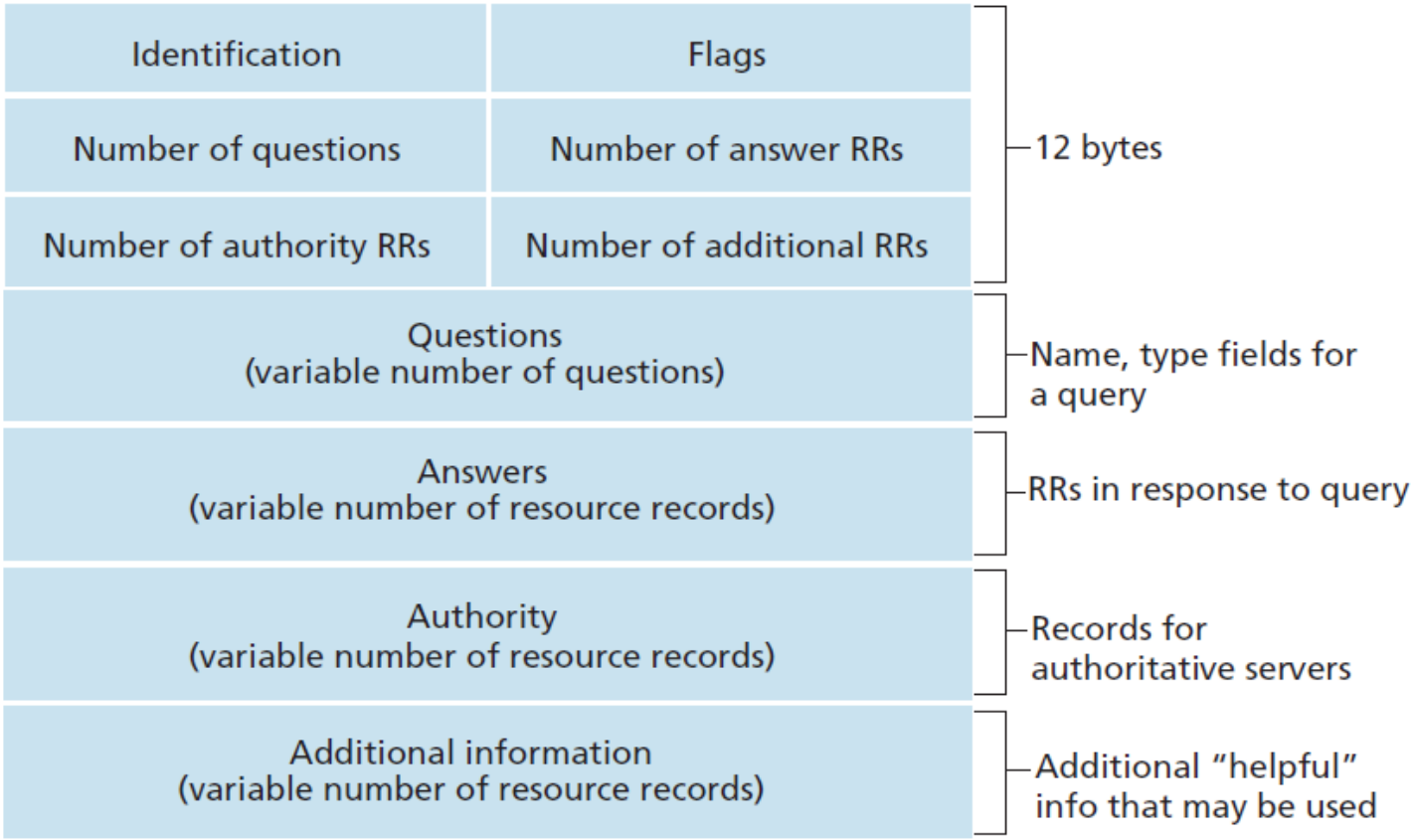


DNS Caching

- Each time a server receives a query for a name that is not in its domain, it needs to search its database for a server IP address.
- Reduction of this search time would increase efficiency.
- DNS server handles this with a mechanism called *caching*
- Caching speeds up resolution, but it can also be problematic by sending outdated mapping.
- To counter this, TTL (time-to-live) based technique is used.

DNS Messages

- The identification field is used by the client to match the response with the query.
- The flag field defines whether the message is a query or response.



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- DNS can use either UDP or TCP.
- In both cases the well-known port used by the server is port 53.

- Example:
  - In UNIX and Windows, the *nslookup* utility can be used to retrieve address/name mapping.

```
$nslookup www.forouzan.biz
Name:  www.forouzan.biz
Address: 198.170.240.179
```

Thanks!