上海交通大學
Shanghai Jiao Tong University

Computer Networks
CS3953

Application Layer-Part 2

Haiming Jin

The slides are adapted from those provided by Prof. Romit Roy Choudhury.

Chapter 2: Application layer

- 2.1 Principles of network applications
- 2.2 Web and HTTP
- 2.3 FTP
- 2.4 Electronic Mail
  - SMTP, POP3, IMAP
- 2.5 DNS

DNS: Domain Name System

People: many identifiers:

- 身份证号，SSN, name, passport #

Internet hosts, routers:

- IP address (32 bit) - used for addressing datagrams
- "name", e.g., www.yahoo.com - used by humans

Q: map between IP addresses and name ?

Domain Name System:

- ***distributed database*** implemented in hierarchy of many *name servers*
- *application-layer protocol* host, name servers to communicate to *resolve* names (address/name translation)
  - note: core Internet function, implemented as application-layer protocol
  - complexity at network's "edge"

DNS: Domain Name System

- Imagine a world without DNS

- You would have to remember the IP addresses of
  - Every website you want to visit
  - Your bookmarks will be a list of IP addresses

  - You will speak like

    "I went to 167.33.24.10, and there was an awesome link to 153.11.35.81… "

DNS

DNS services

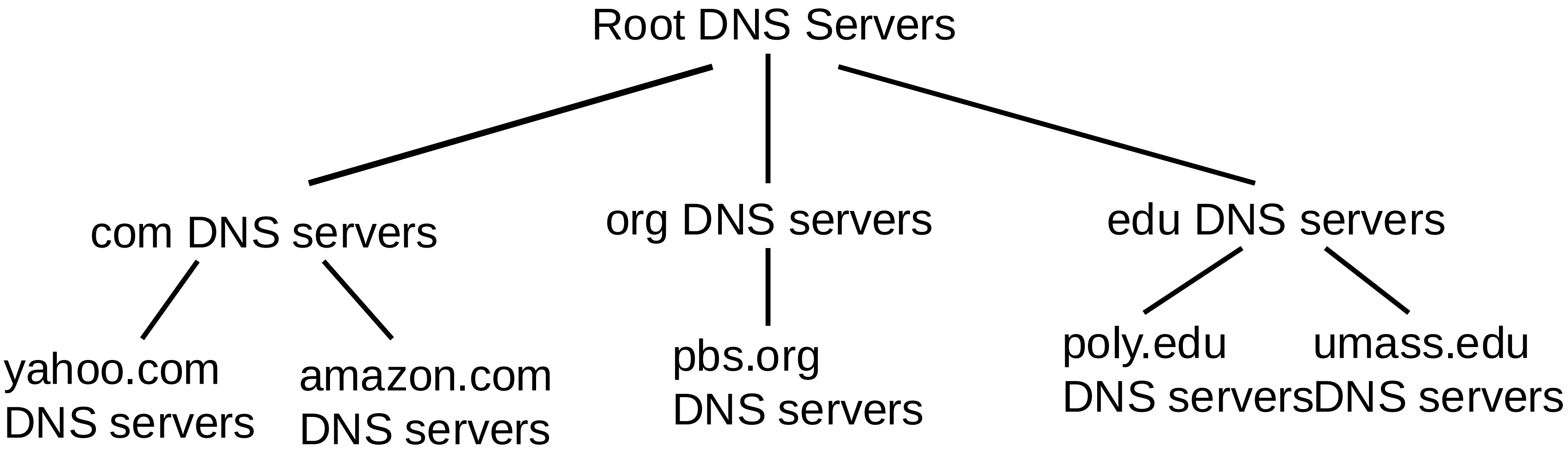
- Hostname to IP address translation
- Host aliasing
    - Canonical and alias names
- Mail server aliasing
- Load distribution
    - Replicated Web servers: set of IP addresses for one canonical name

Why not centralize DNS?

- single point of failure
- traffic volume
- distant centralized database

doesn’t *scale!*

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

DNS: Root name servers

- official, contact-of-last-resort by name servers that can not resolve name

- ICANN (Internet Corporation for Assigned Names and Numbers) manages root DNS domain

13 logical root name "servers" worldwide each "server" replicated many times (~400 around the world)

TLD and Authoritative Servers

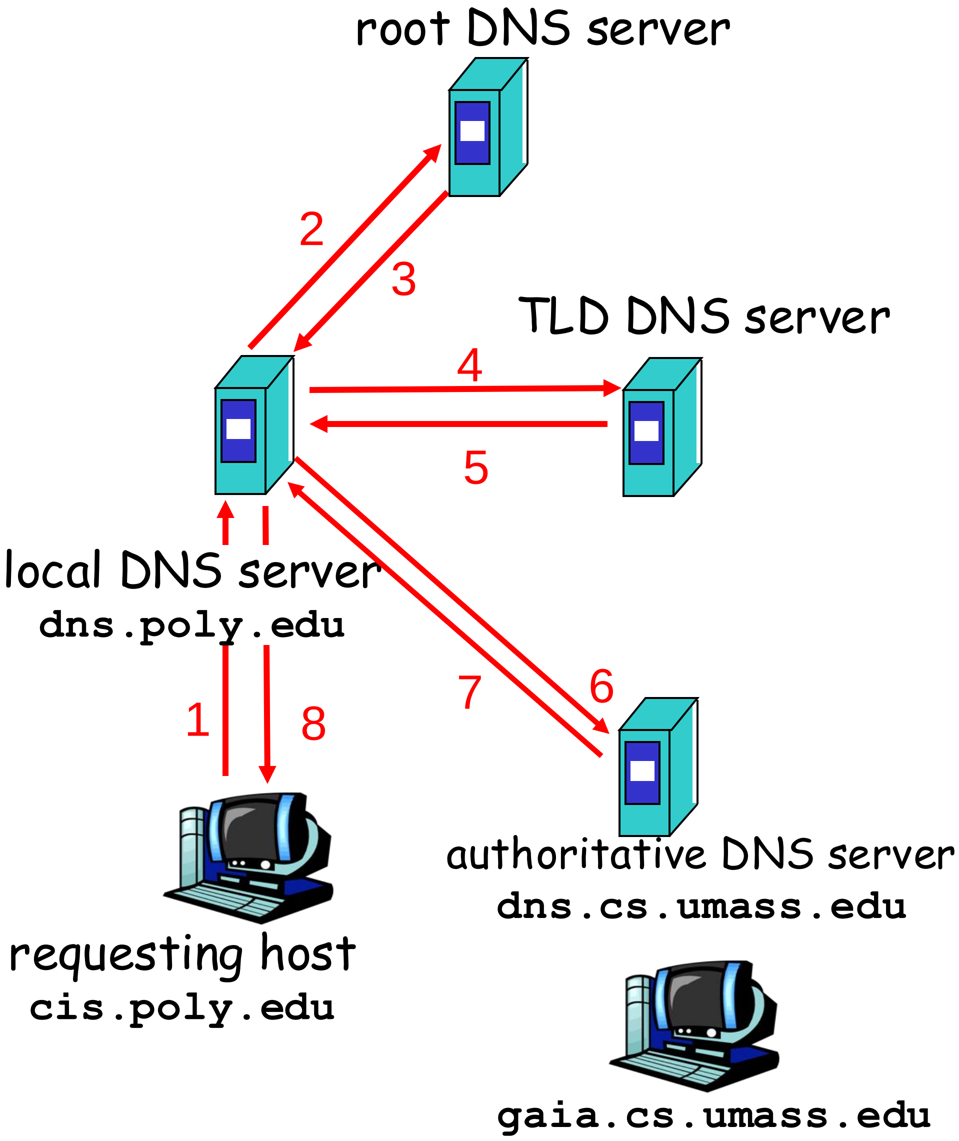
- Top-level domain (TLD) servers:
  - responsible for com, org, net, etc.
- Authoritative DNS servers:
  - An organization’s DNS servers,
    - providing authoritative hostname to IP mappings for organization’s servers (e.g., Web and mail).
  - Can be maintained by organization or service provider

Local Name Server

- Does not strictly belong to hierarchy
- Each ISP (residential, company, univ) has one.
  - Also called "default name server"
- When a host makes a DNS query
  - query is sent to its local DNS server
  - Acts as a proxy, forwards query into hierarchy.

Example

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



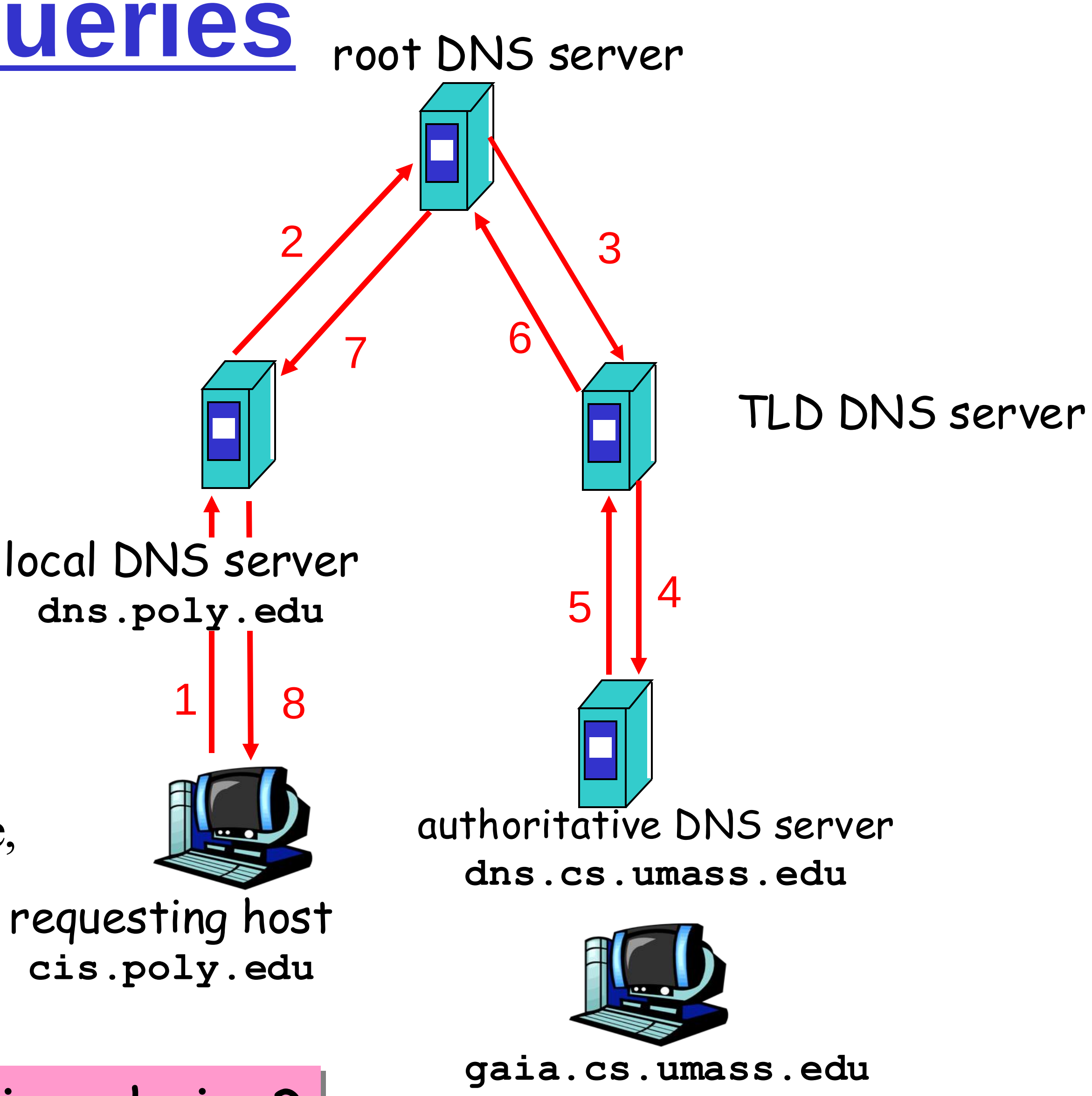
Recursive queries

recursive query:

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

iterative query:

- contacted server replies with name of server to contact
- “I don’t know this name, but ask this server”


root DNS server

TLD DNS server

local DNS server
dns.poly.edu

authoritative DNS server
dns.cs.umass.edu

requesting host
cis.poly.edu

gaia.cs.umass.edu

Which is a better design choice?

DNS: caching

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

DNS records

DNS: distributed db storing resource records (RR)

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

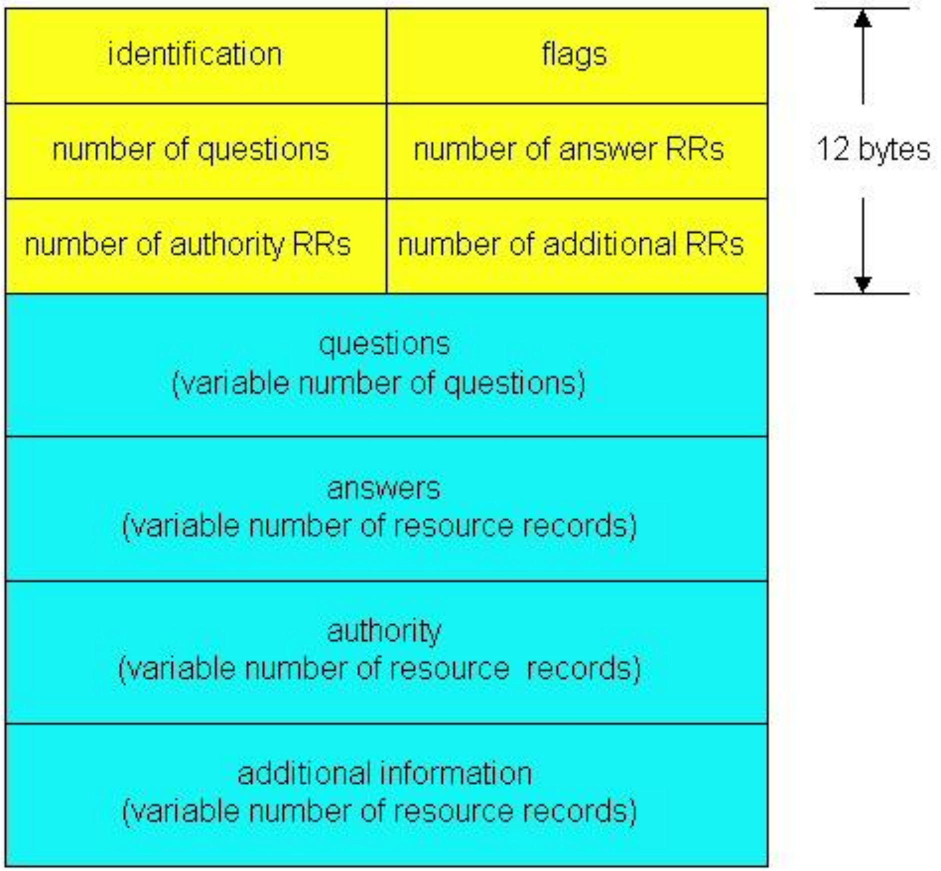
- Type=A
  - **`name`** is hostname
  - **`value`** is IP address
- Type=NS
  - **`name`** is domain (e.g. foo.com)
  - **`value`** is hostname of authoritative name server for this domain
- Type=CNAME
  - **`name`** is alias name for some "canonical" (the real) name `www.ibm.com` is really `servereast.backup2.ibm.com`
  - **`value`** is canonical name
- Type=MX
  - **`value`** is name of mailserver associated with **`name`**

DNS protocol, messages

DNS protocol : *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



identification | flags

number of questions | number of answer RRs

number of authority RRs | number of additional RRs

12 bytes

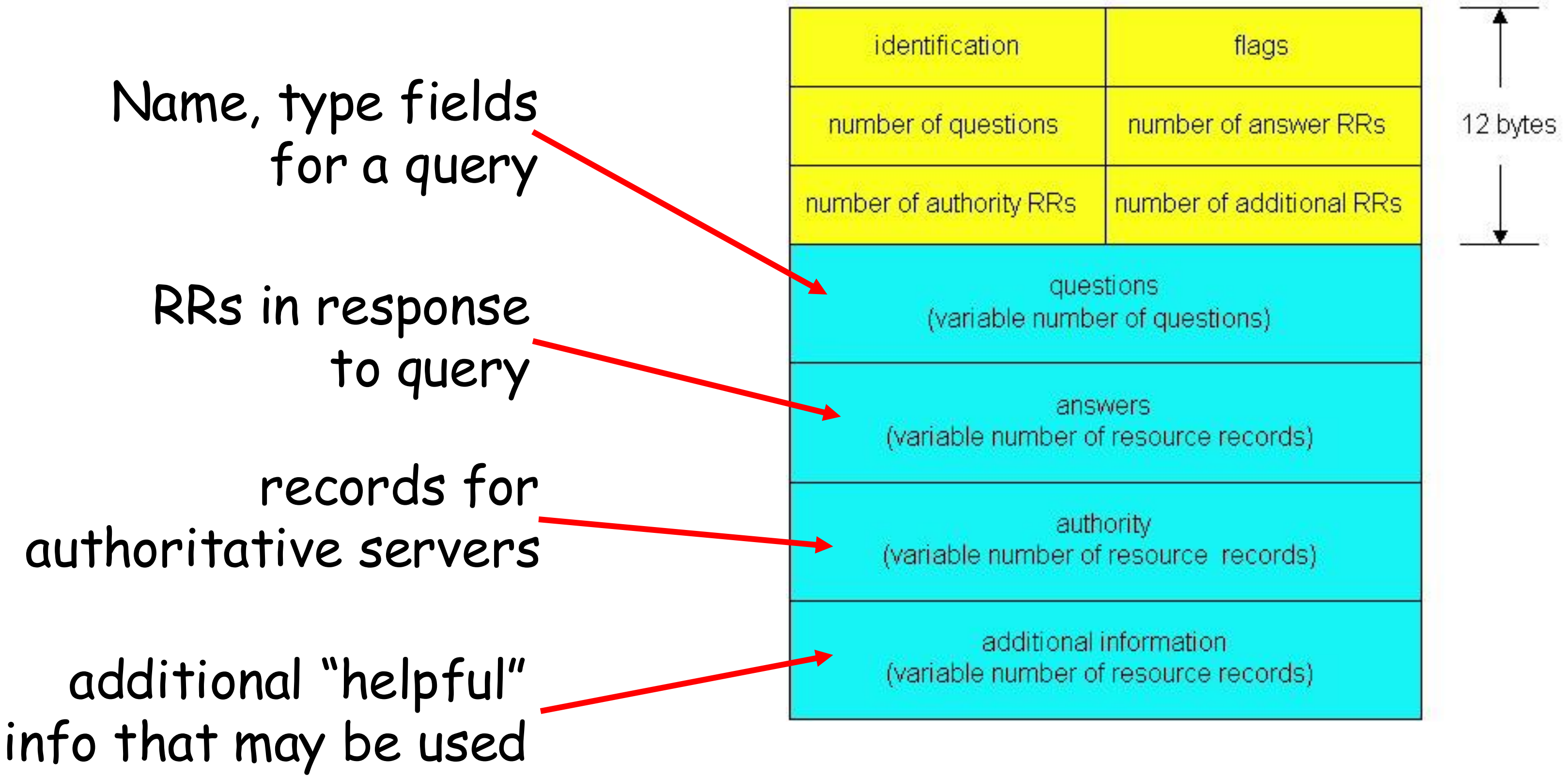
questions
(variable number of questions)

answers
(variable number of resource records)

authority
(variable number of resource records)

additional information
(variable number of resource records)

DNS protocol, messages



Name, type fields for a query

RRs in response to query

records for authoritative servers

additional "helpful" info that may be used

identification	flags
number of questions	number of answer RRs
number of authority RRs	number of additional RRs
questions (variable number of questions)	
answers (variable number of resource records)	
authority (variable number of resource records)	
additional information (variable number of resource records)	

Questions ?

Chapter 2: Summary

Our study of network apps now complete!

- Application architectures
  - client-server
  - P2P
  - hybrid
- application service requirements:
  - reliability, bandwidth, delay
- Internet transport service model
  - connection-oriented, reliable: TCP
  - unreliable, datagrams: UDP
- specific protocols:
  - HTTP
  - FTP
  - SMTP, POP, IMAP
  - DNS
- socket programming

Chapter 2: Summary

Most importantly: learned about *protocols*

- typical request/reply message exchange:
  - client requests info or service
  - server responds with data, status code
- message formats:
  - headers: fields giving info about data
  - data: info being communicated

- control vs. data msgs
  - in-band, out-of-band
- centralized vs. decentralized
- stateless vs. stateful
- reliable vs. unreliable msg transfer
- "complexity at network edge"

Questions?